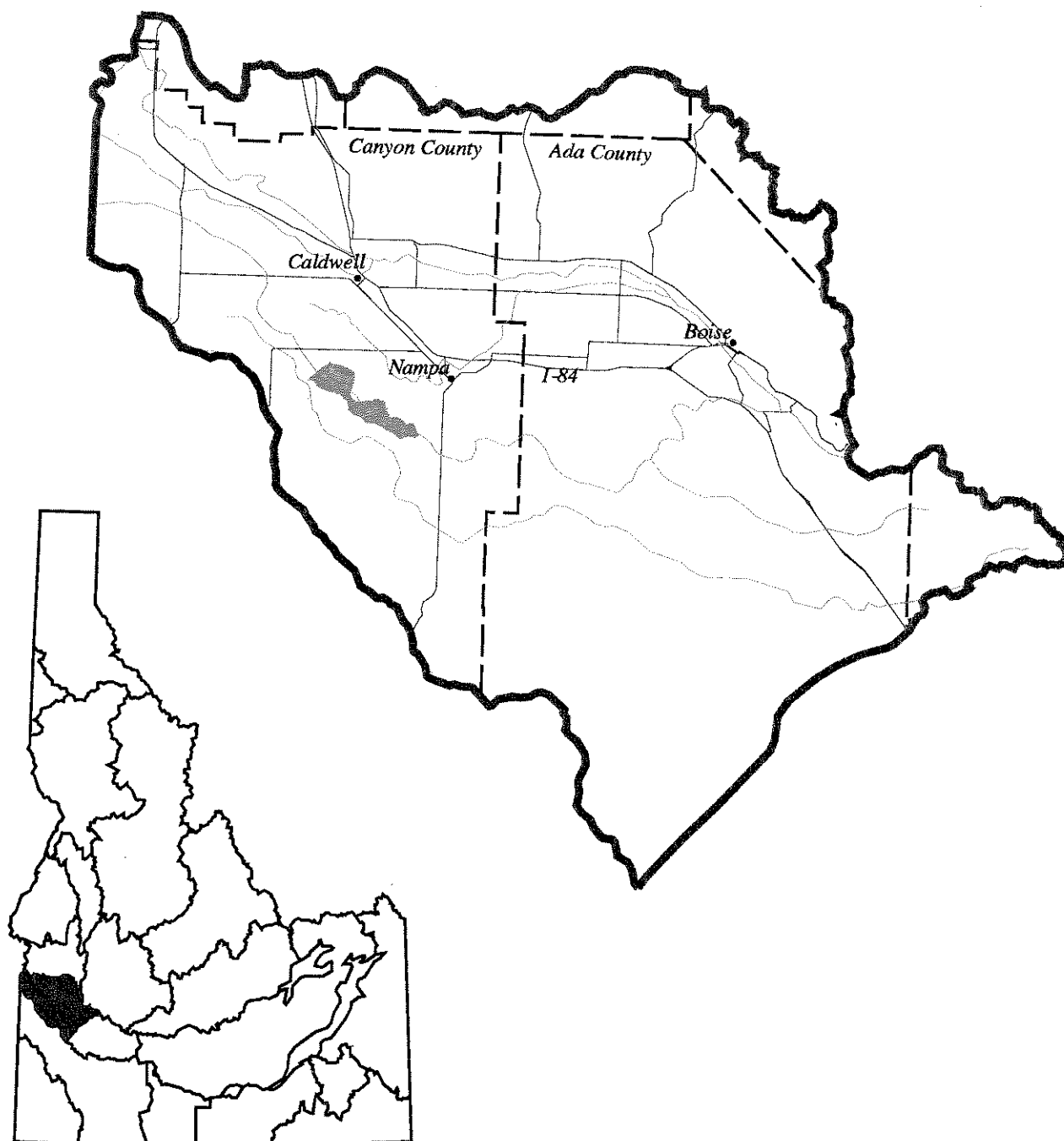


# GROUND WATER QUALITY CHARACTERIZATION AND INITIAL TREND ANALYSIS FOR THE TREASURE VALLEY SHALLOW AND DEEP HYDROGEOLOGIC SUBAREAS

by  
Kenneth W. Neely and Janet K. Crockett



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**Water Information Bulletin No. 50, Part 3  
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## ABSTRACT

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This report describes the ground water quality in the Treasure Valley Shallow (TVS) and Treasure Valley Deep (TVD) hydrogeologic subareas as determined from data collected through the Statewide Ambient Ground Water Quality Monitoring Program (Statewide Program). The Statewide Program is administered by the Idaho Department of Water Resources in cooperation with the United States Geological Survey-Water Resources Division. The TVS and TVD are two of the 20 subareas in the Statewide Program. The TVS and TVD subareas are located primarily in Ada and Canyon counties of southwestern Idaho. Ground water quality data were collected from 144 Statewide Program monitoring sites (existing wells) in the TVS subarea and 137 sites in the TVD subarea during the summer field seasons from 1991 through 1994. Data collection that occurred during these four years is referred to as First Round sampling. Second Round sampling began in 1995. Most of the sites sampled in 1991 through 1993 were re-sampled in 1995 through 1997, respectively. Ground water quality was characterized for the two subareas using First Round data. Initial trend analyses were conducted using Second Round data.

Aquifers in the TVS subarea occur in the unconsolidated gravels and coarse grained sands of the Snake River Group. Aquifers in the TVD subarea consist of the fine to medium grained sands and occasional gravels that are often interbedded with thick clay layers. TVD aquifers occur primarily in the Idaho Group. The top of the TVD subarea was usually determined by the first occurrence of blue or gray clay in the well cuttings.

Characterization of the water quality data collected from 1991 through 1994 indicated that the dominant water types were calcium-bicarbonate and sodium-bicarbonate for both subareas. Trilinear plots showed that the overall water quality was more variable for the TVD subarea than for the TVS subarea. Results from Mann-Whitney rank-sum tests showed that there were significant differences in the median concentrations at the 95 percent confidence level between the two subareas for 18 of the 22 water quality constituents and parameters tested. Overall, ground waters of the TVS subarea were more mineralized than ground waters of the TVD subarea.

The ground water at most of the Statewide Program monitoring sites in the TVS and TVD subareas was suitable for human consumption and other beneficial uses. However, 49 of the 281 sites (17 percent) had one or more constituents with concentrations that exceeded the primary Maximum Contaminant Levels (MCLs) as established by the U.S. Environmental Protection Agency (EPA) for public drinking water supplies. The number of sites with detections above the MCLs was 33 for the TVS subarea (23 percent) and 16 for the TVD subarea (12 percent). Arsenic, bacteria, fluoride, gross alpha, gross beta, nitrate and volatile organic compounds were the constituents detected above existing primary MCLs. Sulfate, total

dissolved solids and uranium had concentration levels above secondary MCLs or proposed primary MCLs.

Nitrate and pesticide data showed that impact to the ground water quality from human activities has occurred in the Treasure Valley, particularly in the TVS subarea. One hundred of the 144 TVS subarea sites (69 percent) had nitrate concentrations equal to or greater than 2.0 milligrams per liter (mg/l) which is the value used by the Statewide Program to distinguish between non-impacted and impacted nitrate levels. The number of sites with nitrate concentrations equal to or greater than 2.0 mg/l for the TVD subarea was 44 (32 percent). One or more pesticides were detected at 32 of 139 TVS sites (23 percent) analyzed by immunoassay methods with detection limits in the parts per billion range. Eighty-two of the 98 TVS sites (84 percent) analyzed by a gas chromatography (GC) method with detection limits in the parts per trillion range had one or more pesticide detections. All immunoassay and GC pesticide detections were below MCLs with most concentrations being at least one order of magnitude below MCLs.

Initial trend monitoring data showed that nitrate concentrations increased at 66 of the 92 TVS subarea sites (72 percent) sampled in the First Round and re-sampled in the Second Round. Individual nitrate increases ranged from 0.03 to 11.9 mg/l. The number of TVS sites with nitrate concentrations greater than the MCL of 10 mg/l increased from two (First Round) to seven (Second Round). Median nitrate values for the TVS subarea increased from 3.35 mg/l (First Round) to 3.87 mg/l (Second Round). Mann-Whitney signed-rank test results indicated that the increase in nitrate medians between the First and Second Rounds for the TVS subarea was significant at the 95 percent confidence level. Median nitrate values for the TVD subarea were 0.87 mg/l (First Round) and 0.69 mg/l (Second Round); these medians were not significantly different at the 95 percent confidence level.

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## INTRODUCTION

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### Statewide Ambient Program

The Ground Water Quality Protection Act, passed by the Idaho State Legislature in 1989, authorized a comprehensive approach for maintaining and improving Idaho's ground water quality. The Act resulted in the formation of the Ground Water Quality Council which developed Idaho's Ground Water Quality Plan in 1992. The monitoring component of the Plan outlined the need for statewide, regional and local ground water quality monitoring. The Idaho Department of Water Resources (IDWR) was tasked with designing and maintaining a statewide ambient ground water quality monitoring network. Regional and local monitoring are the responsibility of the Idaho Department of Health and Welfare-Division of Environmental Quality (IDHW-DEQ) and the Idaho State Department of Agriculture (ISDA). The three parts are to complement each other by allowing different degrees of data resolution (Ground Water Quality Council, 1992).

The Statewide Ambient Ground Water Quality Monitoring Program (Statewide Program) began in 1990 with a limited prototype network of 97 monitoring sites (IDWR, 1991). The Idaho Legislature increased funding for the Statewide Program in 1991 from \$187,300 to \$539,000 per year. The IDWR developed a joint funding agreement with the U.S. Geological Survey (USGS) in 1990 to utilize their strengths in data collection and sample analyses. Since 1991, the USGS has contributed at least \$200,000 annually through federal cooperative funding. The combined State and Federal funds enabled the addition of about 400 sites to the network each year from 1991 through 1994. By the fall of 1994, the Statewide Program network included over 1,500 monitoring sites. The ISDA has also contributed funding since 1993 for pesticide testing.

The IDWR is responsible for the overall administration of the Statewide Program. The IDWR, with assistance from the USGS and the Monitoring Subcommittee, developed the network design and selected the monitoring sites. The IDWR is responsible for analyzing the data and writing interpretative reports. The USGS provides logistical support by: 1) purchasing and distributing field supplies, and 2) conducting the field work which includes inspecting potential monitoring sites, acquiring permission from the site owners, collecting and preserving the ground water samples and shipping the samples to the appropriate laboratories. USGS staff at the District and National level have been consulted throughout the development of the network and during data interpretations. Both the USGS and the IDWR have responsibilities for the ensuring that appropriate Quality Assurance and Quality Control practices are followed.

Currently, samples are analyzed according to the constituent types at either the USGS

National Water Quality Laboratory in Arvada, Colorado, the Idaho State Health Laboratory in Boise, Idaho, or Alpha Analytical Laboratory in Sparks, Nevada.

## **Program Objectives and Purpose of Report**

The objectives of the Statewide Program are:

1. Characterize the ground water quality of the state's aquifers;
2. Identify trends and changes in ground water quality within the state's aquifers; and
3. Identify potential ground water quality problem areas.

Data collected through the Statewide Program from 1991 to 1994, which is called First Round sampling, is being used to address the first objective (characterization) and, to some extent, the third objective (potential problems). Data collected in 1995 through 1998 is Second Round sampling. Second Round sampling and beyond will be used for trend analyses and additional characterization.

The purpose of this report is to: 1) characterize the ground water quality data collected from First Round sampling for the Treasure Valley Shallow and Treasure Valley Deep hydrogeologic subareas (formerly the Boise Valley Shallow and Boise Valley Deep subareas), 2) provide initial results for trend monitoring from Second Round sampling, and 3) discuss the ground water quality concerns that were identified through Statewide Program monitoring. Characterization was accomplished using descriptive and non-parametric statistics, maps depicting constituent concentrations, and graphical tools such as boxplots that show relationships between the constituents. Trend analyses in this report include: 1) time versus concentration plots, and 2) paired sampling analyses for nitrate, total dissolved solids (TDS) and some pesticide results from First and Second Round sampling through 1997. Trend monitoring is currently in the initial phase; more data are needed before comprehensive analyses can be conducted. Ground water quality concerns are discussed for those constituents that had either concentrations exceeding MCLs or that were elevated above the probable natural background levels.

This report is the first in a series of planned reports for the 20 hydrogeologic subareas in the Statewide Program. The Treasure Valley was selected first in response to a need of the Treasure Valley Hydrologic Project (TVHP). One of the project tasks in the TVHP work plan was the utilization of existing Statewide Program data to characterize the ground water quality in the Treasure Valley. This report accomplishes that task.

## **Well-Numbering System**

The well-numbering system used in this report is identical to the system used by the USGS in Idaho (Figure 1). The system indicates the location of wells within the official rectangular subdivision of the Public Land Survey System (PLSS) with reference to the Boise

baseline and meridian. The first two segments of the number designate the township and range. The third segment gives the section number followed by three or four letters and a number. The letters indicate the  $\frac{1}{4}$  section (160 acre tract),  $\frac{1}{4}$ - $\frac{1}{4}$  section (40 acre tract),  $\frac{1}{4}$ - $\frac{1}{4}$ - $\frac{1}{4}$  section (10 acre tract),  $\frac{1}{4}$ - $\frac{1}{4}$ - $\frac{1}{4}$ - $\frac{1}{4}$  section (2.5 acre tract), and the serial number of the well within the tract. Quarter sections are lettered A, B, C, and D in counterclockwise order beginning in the northeast quarter of the section. Successively smaller tracts are lettered in the same manner. For example, well 01N 01E 11DBA1 corresponds to the PLSS location: NE $\frac{1}{4}$ , NW $\frac{1}{4}$ , SE $\frac{1}{4}$ , Section 11, Township 1 North, Range 1 East, and it was the first well inventoried by the USGS in that tract.

## Acknowledgments

The authors would like to thank the following persons for their assistance with the Statewide Program: 1) the U.S. Geological Survey-Water Resources Division in Boise, Idaho, for their dedication to the Statewide Program since its inception in 1990, 2) the Idaho State

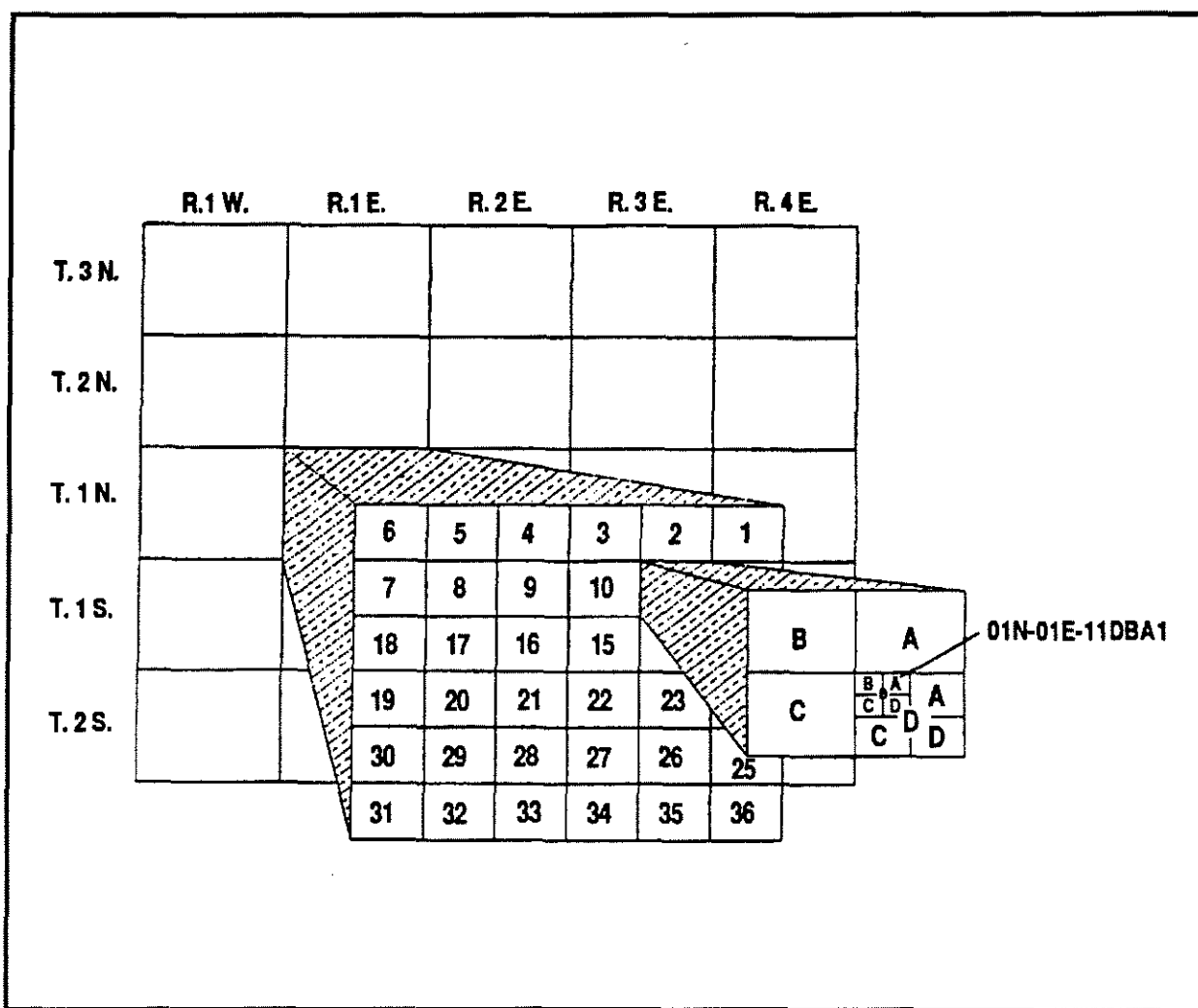


Figure 1. Well-numbering system.

Department of Agriculture for their financial assistance with pesticide testing, 3) the Trend Monitoring Technical Committee for their input regarding characterization and trend monitoring: Gary Bahr (Idaho State Department of Agriculture); Charlie Bidondo, Rob Howarth, Gerry Winter and Dean Yashan (Idaho Department of Health and Welfare-Division of Environmental Quality); Paul Castelin (Idaho Department of Water Resources); Flint Hall (Idaho Department of Health and Welfare-Idaho National Environmental and Engineering Laboratory Oversight Program); and Mark Hardy, Ivalou O'Dell, Mike Rupert and Annette Tungate (U.S. Geological Survey), 4) technical reviewers: Hal Anderson, Paul Castelin, Karl Dreher, Wayne Haas and Scott Urban (Idaho Department of Water Resources); Mark Hardy, Dennis Helsel and Mike Rupert (U.S. Geological Survey); Linda Boyle, Rob Howarth, Gerry Winter and Dean Yashan (Idaho Department of Health and Welfare-Division of Environmental Quality); Flint Hall (Idaho Department of Health and Welfare-Idaho National Environmental and Engineering Laboratory Oversight Program); and Christian Petrich (Idaho Water Resource Research Institute), 5) Sudhir Goyal, Diane Holt and Jessica Larson (Idaho Department of Water Resources) for graphical support, 6) Brian Abbott formerly of the Idaho Department of Health and Welfare, Office of Environmental Health, and Jim Baker of the Idaho State Department of Agriculture for their reviews of health consequences listed in Appendix B, and 7) the Idaho State Department of Agriculture, particularly Gary Bahr, for follow-up investigations of Statewide Program pesticide detections in the Treasure Valley.

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## TREASURE VALLEY SHALLOW AND DEEP HYDROGEOLOGIC SUBAREAS

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### Location

The Treasure Valley is located in Ada and Canyon counties of southwestern Idaho (Figure 2). The area contains two of the 22 Hydrogeologic Subareas delineated for the Statewide Program: the Treasure Valley Shallow and the Treasure Valley Deep (Figure 3). These two subareas lie in the western part of the Snake River Plain (Figure 4). The Snake River Plain is an arcuate topographical and structural depression extending from Yellowstone Park, Wyoming, across southern Idaho and into eastern Oregon (Newton, 1989).

The Treasure Valley Deep (TVD) subarea consists primarily of the Idaho Group aquifers which are greater in areal extent than the alluvial aquifers of the Treasure Valley Shallow (TVS) subarea (Figure 5) (a detailed discussion of the aquifer systems is presented in the Hydrogeology section). The TVD subarea's northern and eastern boundaries are Hydrologic

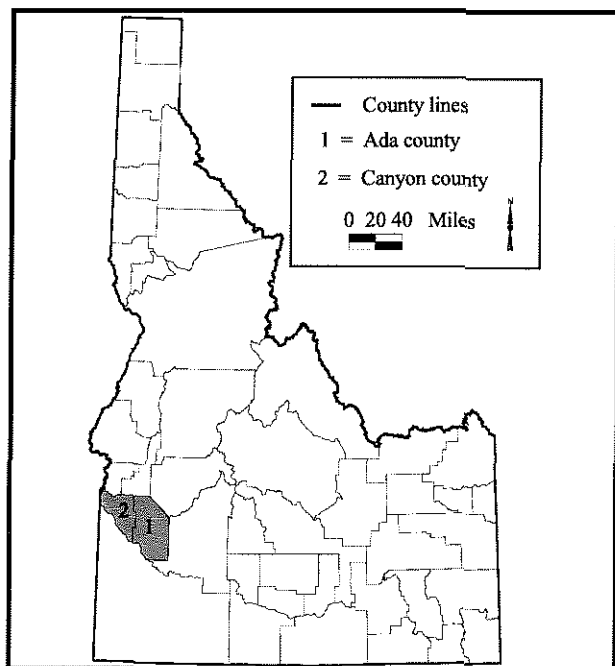


Figure 2. Location of the Treasure Valley in Ada and Canyon counties.

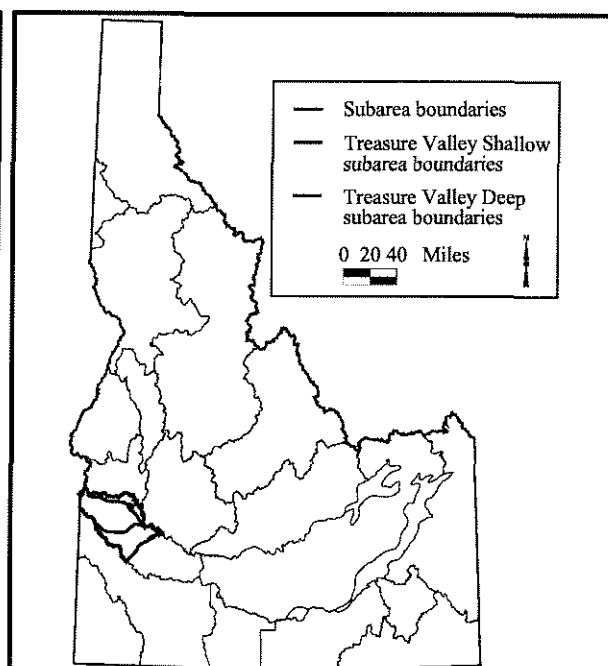


Figure 3. Location of the Treasure Valley Shallow and Treasure Valley Deep Hydrogeologic Subareas.

Unit boundaries which were defined as surface water flowpath boundaries by the United States Geological Survey (1974). The northern boundary is the surface water divide between the Treasure Valley to the south and the Lower Payette Valley to the north and it lies just north of the Ada and Canyon county lines. The eastern boundary is a combination of three Hydrologic Unit boundaries which delineate the Treasure Valley from the Boise Mountains to the northeast and the Mountain Home Plateau to the southeast. The western boundary for both subareas is the Idaho-Oregon state line. The TVS subarea partially overlies the TVD subarea. The northern, eastern and southern boundaries of the TVS subarea are the lateral extents of the shallow alluvial aquifers (Figure 5). The western boundaries are the Snake River and the Idaho-Oregon border.

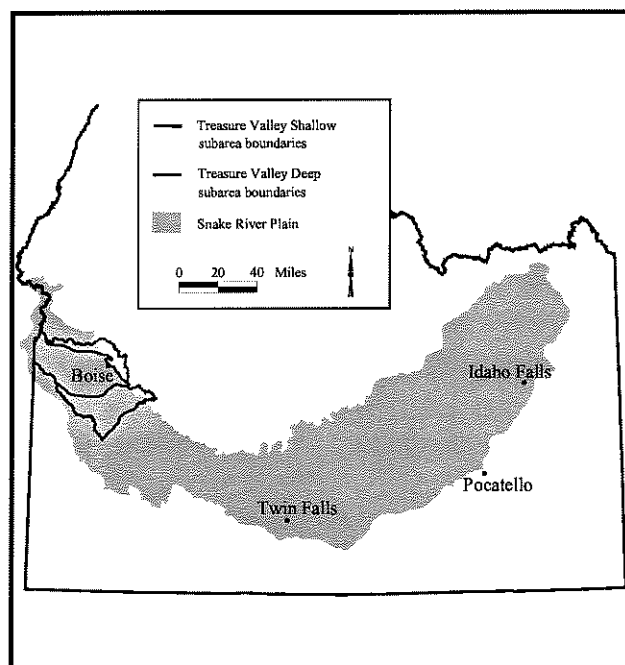


Figure 4. Location of the Treasure Valley Shallow and Deep subareas and the Snake River Plain.

## Geography

The Treasure Valley is a broad, relatively flat plain bordered by the Boise Front Foothills to the northeast and the Owyhee Foothills to the southwest (Figure 5). The area is dissected by the Snake and Boise rivers. Several step-like terraces or benches exist on both the northern and southern sides of the Boise River, but they are better developed and more continuous on the southern side (Figure 6) (Dion, 1972; Othberg, 1994). The Snake River Canyon, located along the southern edge of the Treasure Valley Deep subarea boundary, ranges in depth from 100 to 700 feet (Newton, 1989). The valley floor descends from about 3,000 feet above sea level near Lucky Peak Dam to about 2,200 feet at the mouth of the Boise River with a gradient of about 10 feet per mile to the northwest (Thomas and Dion, 1974). Surface waters

include the Boise River and its tributaries, two man-made reservoirs (Lake Lowell and Barber), numerous canals and several lakes.

## Climate

The Treasure Valley has a temperate climate with hot dry summers and cool wet winters (Dion, 1972). The mean annual temperature is 51.0° Fahrenheit with January and July having the coldest and warmest mean temperatures, respectively (29.0° and 74.0° Fahrenheit)(National Oceanic and Atmospheric Administration, 1996). The Boise Front Foothills, located northeast of the Boise Airport, receive about 65 percent more precipitation annually than the valley floor



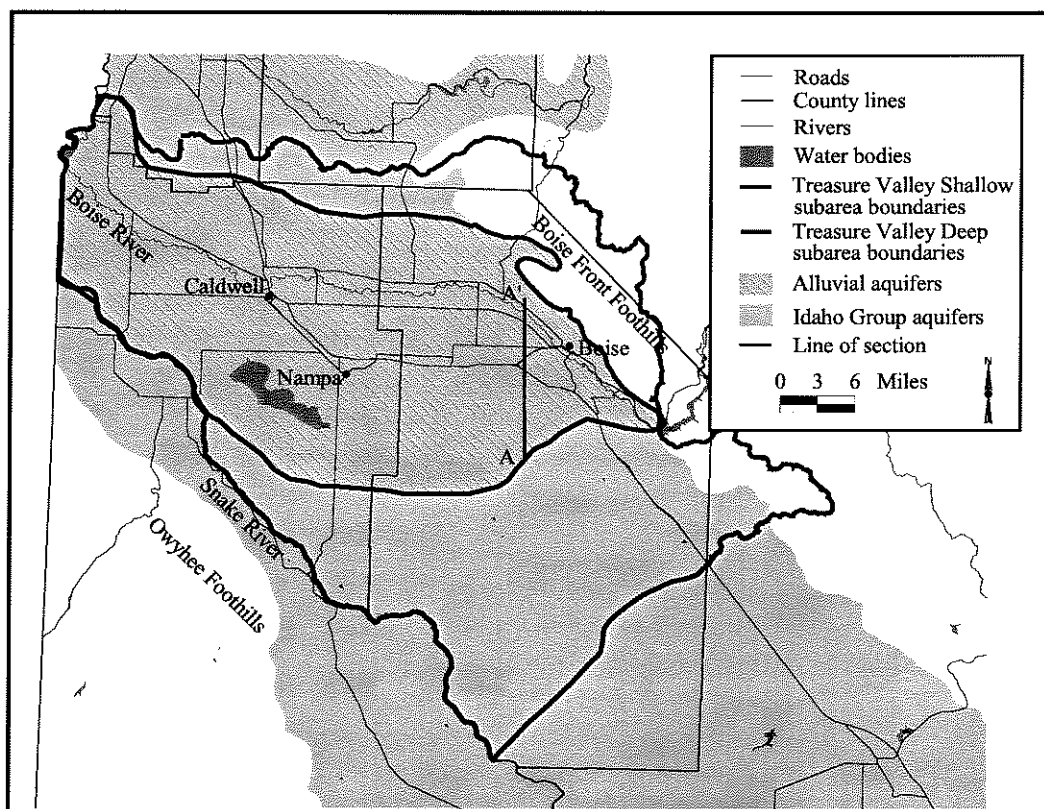


Figure 5. Subarea boundaries and aquifer types for the Treasure Valley Shallow and Deep subareas.

(Figures 7 and 8). Precipitation for the water years (October 1 through September 30) of 1991, 1992 and 1994 was lower than the 30 year average; water years 1993, 1995, 1996 and 1997 were higher than average (Figure 8). Precipitation at the Boise Airport rain gauge was about 4 percent lower for water years 1991-1997 than for the 30 year average.

## Demographics

The population for Ada and Canyon Counties was estimated to be 347,768 on July 1, 1994 with approximately 78 percent of the people residing in urban areas and 22 percent living in rural settings (Idaho Department of Commerce, 1994, 1995). The combined population for the TVS and TVD subareas is slightly more than the populations for the two counties because the two subareas include small portions of Elmore, Gem and Payette Counties. The Treasure Valley (Ada and Canyon counties) experienced a population increase of about 18 percent from 1990 to 1994.

## Land Use and Ground Water Vulnerability

Agriculture, urban and rangeland are the main land uses in the Treasure Valley with

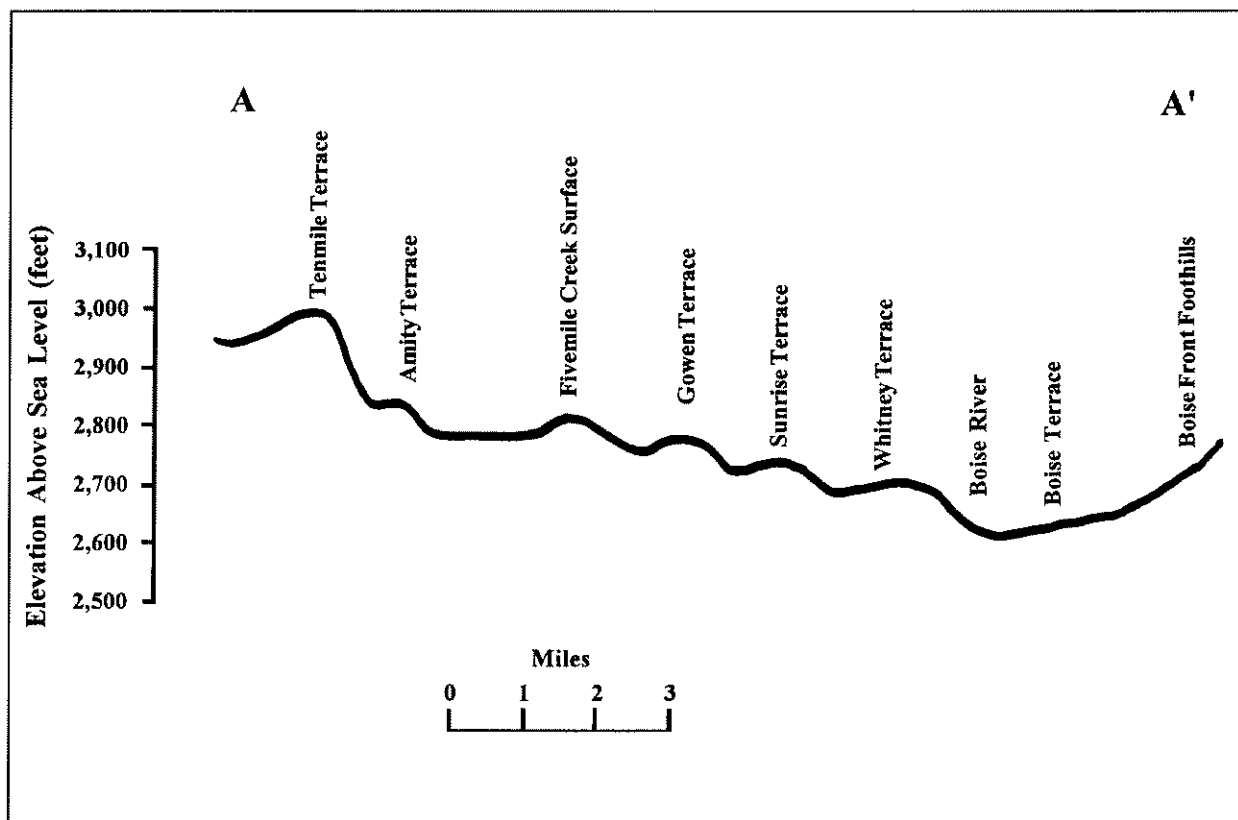


Figure 6. Profile showing the terraces adjacent to the Boise River (modified from Othberg, 1994). Location of the Line of Section is shown in Figure 5. Vertical exaggeration = 42:1.

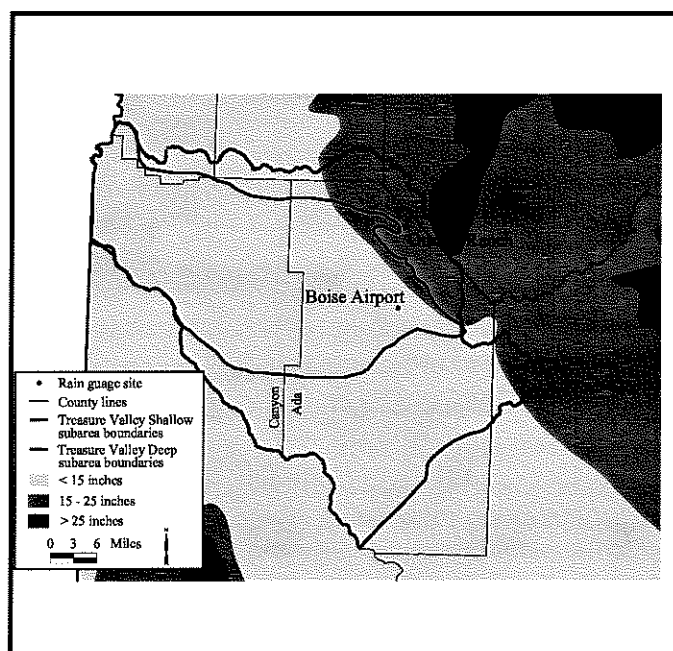


Figure 7. Precipitation contour map for the Treasure Valley and surrounding area.

irrigated agriculture being the dominant land use (Figure 9) (Kramber and others, 1997). The cities and towns of Boise, Nampa, Caldwell, Meridian, Eagle, Star, Middleton and several other smaller communities comprise the urban areas. Agriculture is common in the central and western parts of the valley; rangeland occurs in the northern and eastern areas.

Ground water vulnerability (GWV) mapping is a method that has been developed and used to rate areas within Idaho for their relative ground water pollution potential (Rupert and others, 1991). Ground water vulnerability ratings range from low to very high for the Treasure Valley area (Figure 10).

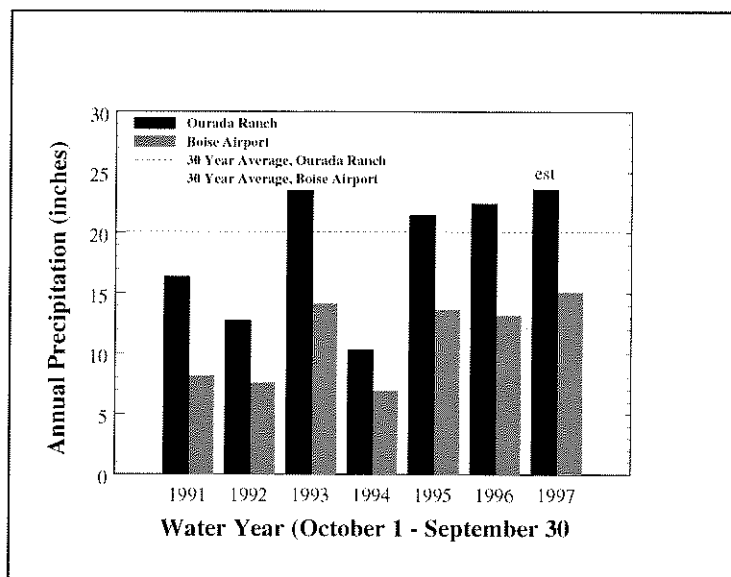


Figure 8. Precipitation records for the Ourada Ranch and Boise Airport rain gauges.

The north central part of the subarea, which is dissected by the Boise River, is rated very high. Areas to the north and south of the Boise River have lower ground water vulnerability ratings with the exception of a very high ground water vulnerability area in the southwestern part of the subarea along the Snake River. Urban areas comprise a large portion of the ground water vulnerability ratings in and around Boise, Nampa and Caldwell (Figure 10).

Recent work by Rupert (1997a) in the eastern Snake River Plain (SRP) has shown that the previous ground water vulnerability

maps can be improved considerably by calibrating the vulnerability point ratings to actual ground water quality data. Rupert (1997a) made statistical comparisons of nitrate data collected by the Statewide Program to soils, land uses and depth to ground water. Rupert developed a vulnerability point rating scheme based upon those statistical comparisons. The resulting maps, called "nitrate probability maps", show statistically-significant differences in nitrate concentrations between probability categories at greater than a 99 percent confidence level. The vulnerability maps produced in 1991 for the western SRP (Rupert and others, 1991) should be used cautiously until probability maps are constructed. Then, ground water vulnerability maps and probability maps can be used together to understand and predict the relationships between land use and ground water quality contamination (existing or potential).

## Previous and Current Investigations

Numerous geologic, hydrogeologic and ground water quality studies have been conducted in the Treasure Valley area. Studies on the Snake River Plain regional aquifer system were conducted by Newton (1989), Wood and Low (1987, 1988) and Lindholm (1993). Dion (1972) described the effects of land use on the shallow aquifer system in the Boise-Nampa area. Thomas and Dion (1974) reported the ground water conditions in areas near the Boise River. Wood (1979) characterized the geology in the Nampa-Caldwell area. Squires and others (1992) provided a hydrogeologic framework for the Boise aquifer system in Ada County. Other studies and geologic maps that cover portions of the Treasure Valley have been completed by Ralston and Chapman (1970), Glover (1981), Burnham and Wood (1992) and Othberg and Stanford (1992).

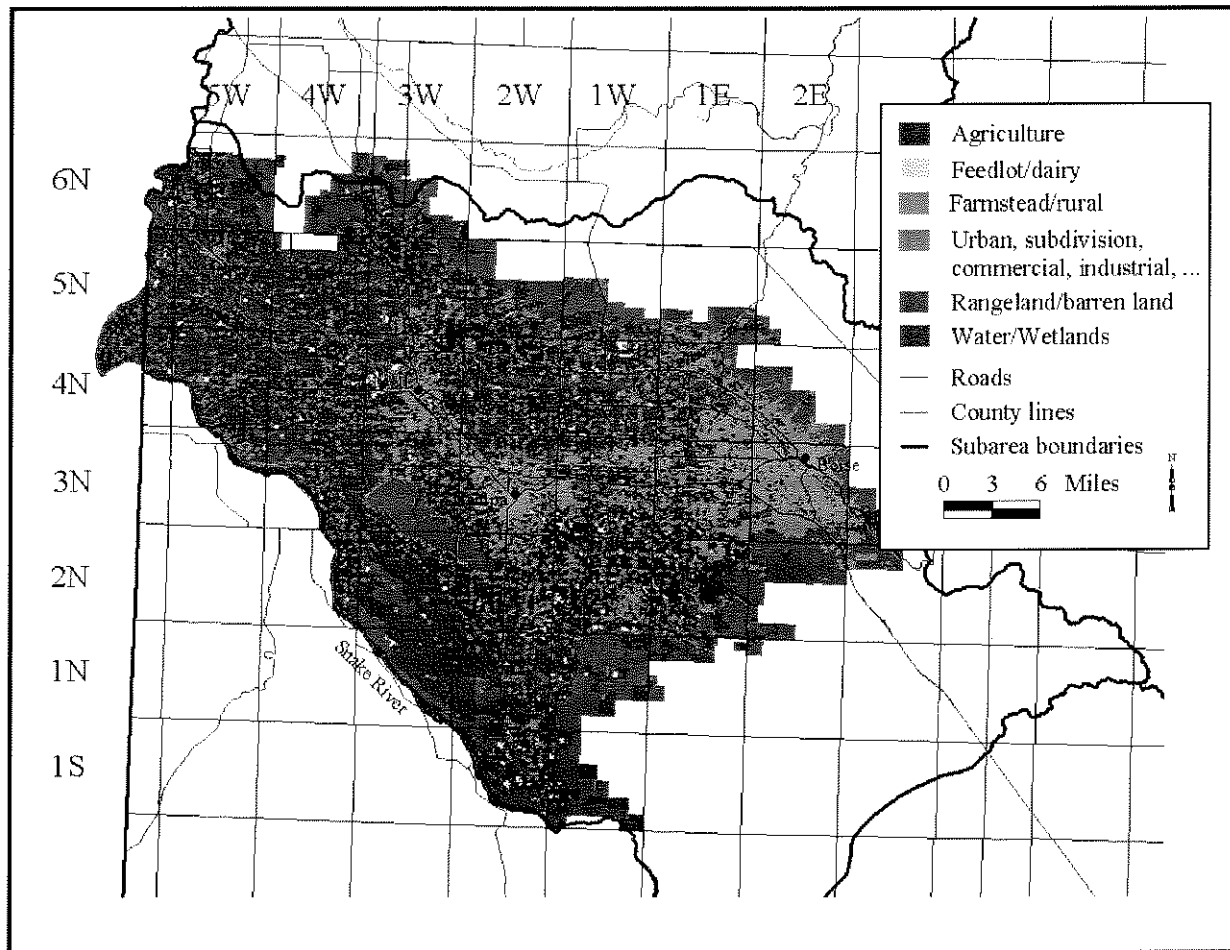


Figure 9. Land uses in the Treasure Valley (modified from Kramber and others, 1997).

The IDHW-DEQ and the USGS conducted two studies to determine the nature and extent of ground water contamination in the Boise City area and the lower Boise River Valley (Boyle, 1995, 1996). Ground water chemistry data were reported for selected wells in the Treasure Valley by Parlman (1982) and Parlman and others (1996).

The Treasure Valley Hydrologic Project (TVHP) is a comprehensive investigation that began in 1996. The purpose of the TVHP is to develop a better understanding of the water resources in the Treasure Valley. The multi-agency effort is evaluating effects of growth and land use changes on the regional and local ground water supplies. The project is being conducted in three phases over a five year period. The first phase included field investigations (surface water and ground water level measurements), establishing a long-term monitoring network, developing a one-year water budget for the Treasure Valley (Urban and Petrich, 1998) and developing a preliminary ground water computer model (Petrich, 1997).

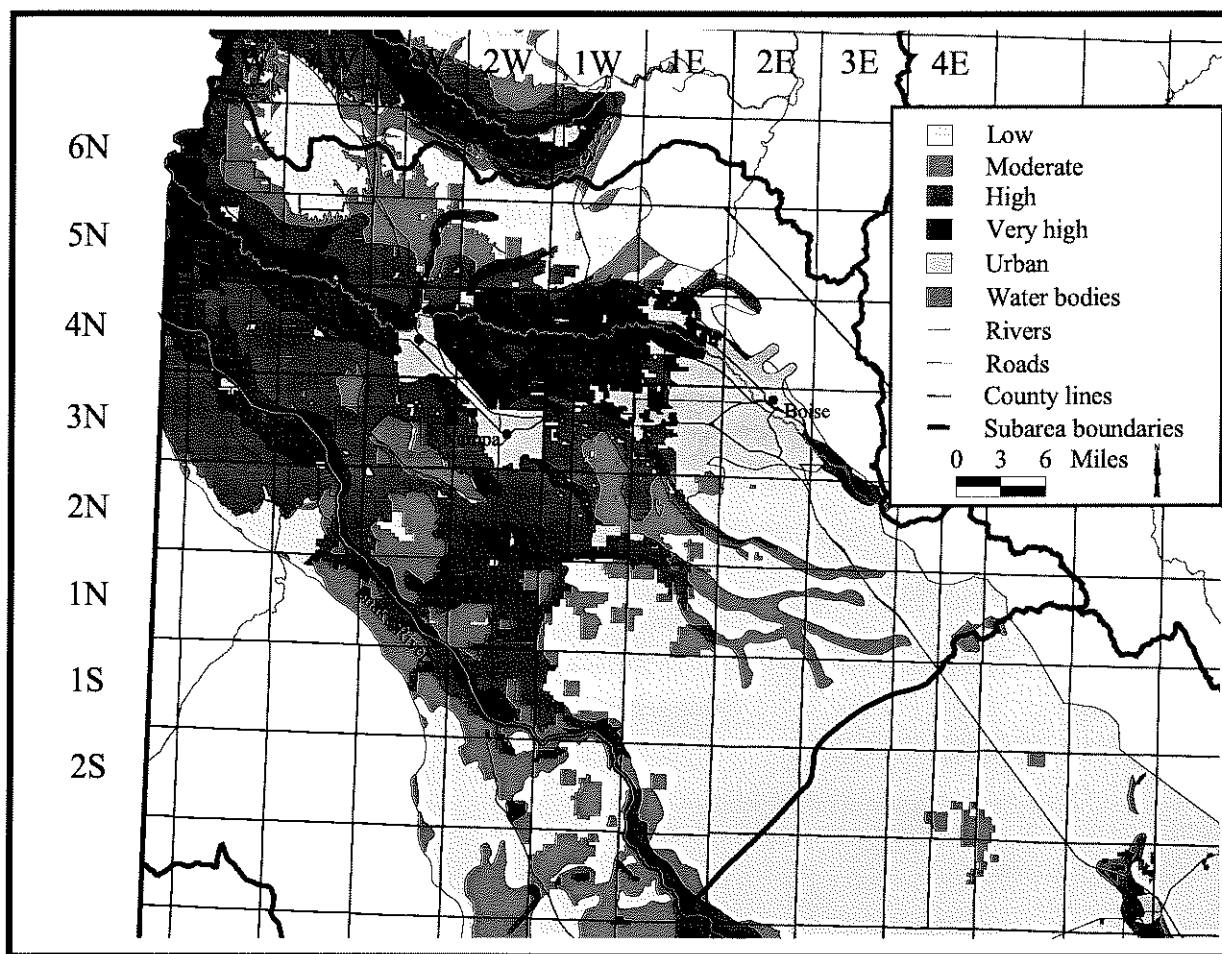


Figure 10. Ground water vulnerability ratings for the Treasure Valley (modified from Rupert and others, 1991).

The second phase of the TVHP began in July, 1997, and is scheduled to continue until July, 1999. The second phase includes (contingent on funding) continued ground water monitoring, characterization of ground water recharge mechanisms and areas, continued subsurface characterization, calibration of the numerical ground water flow model and sensitivity analysis of model parameters.

## Hydrogeology

### Previous and Current Studies

The hydrogeology in the Treasure Valley is complex because of the depositional and structural history of the area. There are five geologic groups containing one or more formations (Table 1). The Snake River and Idaho Groups are the main groups of interest in this report because they contain the drinking water aquifers used by Treasure Valley residents. The

formations in the Idaho Group contain fine grained sediments and aquifers that may be regional in extent. Idaho Group aquifers are usually confined or partially confined. The Snake River Group overlies the Idaho Group and contains coarse grained sediments and some localized basalt flows, especially in the southern parts of the Treasure Valley (Othberg and Stanford, 1992). The lateral and vertical extents of the Snake River Group aquifers are generally less than those of the Idaho Group aquifers.

The overall ground water flow direction is to the west with some southwest and northwest components (Figure 11). This ground water flow map currently represents a compilation of water level data from both the TVS and TVD aquifers.

Dion (1972) was the first investigator to recognize two general aquifer systems in the Treasure Valley which he called the Deep and Shallow (Table 1). The Deep Aquifer, according to Dion (1972), includes the Idaho Batholith, Columbia River, Idavada and Idaho Groups. The Shallow Aquifer includes the gravels and basalts of the Snake River Group. Dion (1972) described in detail the hydrogeologic relationships in the Shallow Aquifer.

Table 1. Aquifer or layer delineations from selected hydrogeologic investigations for the Treasure Valley.

<b>AUTHORS ► GROUP ▼</b>	<b>Dion, 1972</b>	<b>Newton, 1989<sup>1</sup></b>	<b>Squires and others, 1992</b>	<b>Treasure Valley Hydrologic Project (in progress)<sup>1</sup></b>	<b>Statewide Program</b>
<b>Snow River Group<sup>2</sup></b>	Shallow Aquifer	Upper Unit	N/A	Layer 1	Treasure Valley Shallow
<b>Idaho Group<sup>3</sup></b>	Deep Aquifer	Middle Unit	Five Facies (Ada County)	Layers 2-4	Treasure Valley Deep
<b>Idavada Group<sup>4</sup></b>		Lower Unit	N/A	N/A	N/A
<b>Columbia River Group<sup>5</sup></b>					
<b>Idaho Batholith Group<sup>6</sup></b>					

<sup>1</sup> These delineations were made on the basis of numerical model design and are not precise stratigraphic descriptions.

<sup>2</sup> Unconsolidated alluvium, Bonneville flood deposits, terrace gravels, discontinuous basalt flows.

<sup>3</sup> Glens Ferry, Pierce Gulch, Payette, Poison Creek, Succor Creek, Terteling Springs and Chalk Hills Formations (which are mostly lacustrine sediments consisting of fine-grained sands, silts and clays), discontinuous basalt flows and the Banbury Basalt.

<sup>4</sup> Boise Front rhyolites.

<sup>5</sup> Basalt.

<sup>6</sup> Granite.

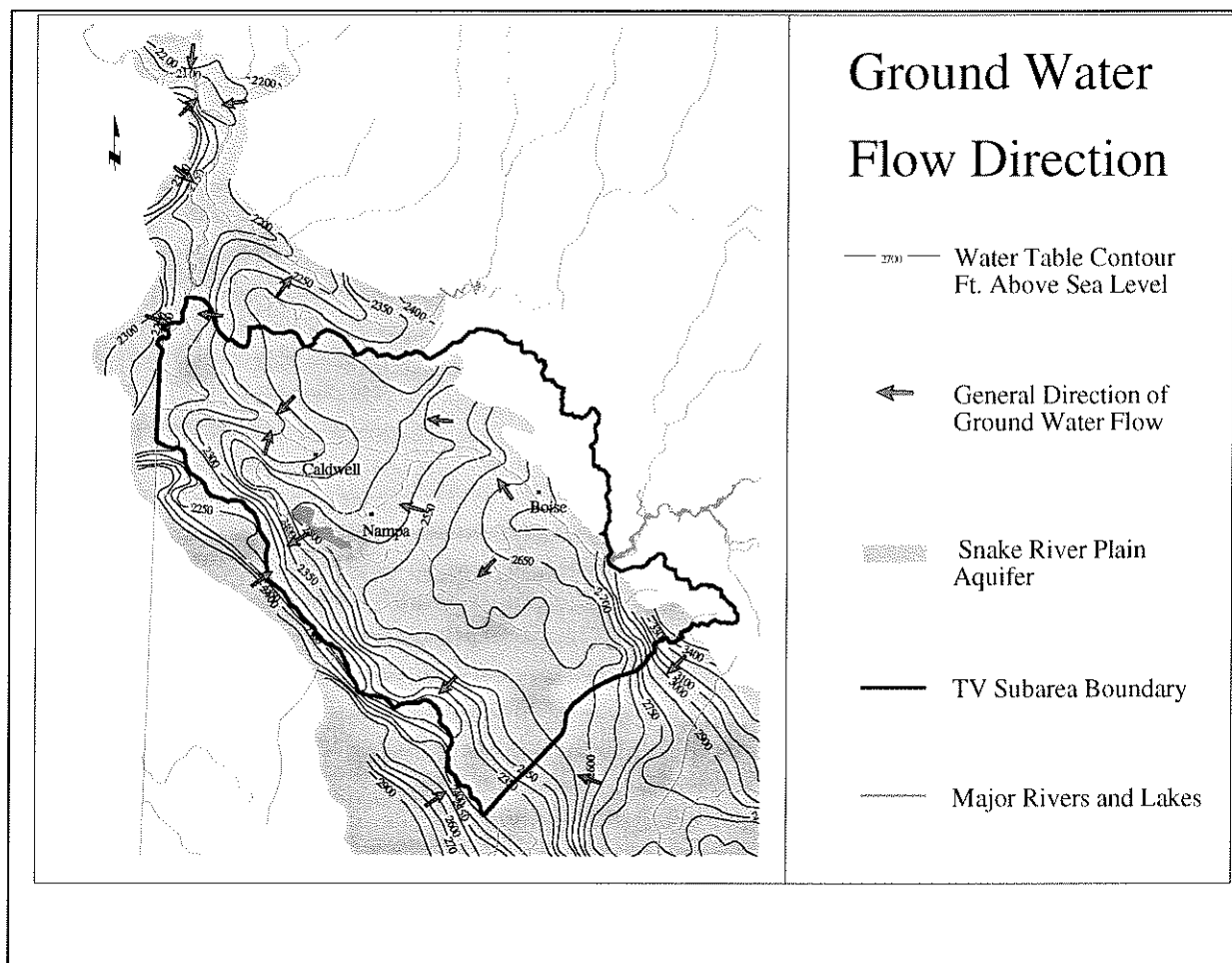


Figure 11. Generalized ground water flow directions for the Treasure Valley (modified from Newton, 1989).

Newton (1989) delineated three major rock units called the Lower, Middle and Upper (Table 1). Newton's (1989) units were based on generalized Treasure Valley hydrogeology and used in his ground water flow model. The Lower Unit contains volcanic rocks (rhyolites and basalts) and the ground water from this unit is geothermal (equal to or greater than 29.4° Celsius (C)). The Middle Unit is a thick (about 4,000 feet) section of primarily sedimentary rocks. The clay layers are up to several hundred feet thick and considered to be confining. The sand layers are generally fine grained. The Upper Unit was described as a 500-feet thick zone comprised mainly of unconfined to partially confined sand and gravel aquifers. It appears that the Upper Unit includes all of the Snake River Group and the upper part of the Idaho Group in some places.

Squires and others (1992) described five facies of the Boise aquifer system in Ada County: 1) alluvial fan deposits, 2) fan to lake transition, 3) lake deposits, 4) deep lake deposits, and 5) river sands. The facies are interpreted to reflect deepening water conditions from the southeast area of Boise (alluvial fan) to the northwest area (deep lake). It appears that these five

facies are equivalent to part of the Middle Unit of Newton (1989) (Table 1).

### Statewide Program

The cold water aquifer system of the Treasure Valley was divided into two subareas for the Statewide Program based primarily on the work completed by Dion (1972) and Newton (1989). The Treasure Valley Deep (TVD) subarea is equivalent to the Middle Unit of Newton (1989) and to the Deep Aquifer of Dion (1972) with the exclusion of the volcanic geothermal aquifers (Table 1). The five facies in Ada County described by Squires (1992) are interpreted to be in the TVD subarea. The Treasure Valley Shallow (TVS) subarea is probably the same as the Shallow Aquifer of Dion (1972) and the Upper Unit of Newton (1989) (with the possible exception of the base of the Upper Unit). In general, the TVS subarea is equivalent to the Snake River Group and the TVD subarea correlates to the Idaho Group. However, detailed hydrostratigraphic relationships have yet to be determined.

Lithologic descriptions, well depth, confining conditions of the aquifer and water quality field parameters were used as guidelines to distinguish between subareas. The absence or presence of blue or gray clay was an important feature in the lithologic descriptions. Aquifers above the blue or gray clay often consisted of coarse grained gravels and sands. These aquifers were unconfined to partially confined and either in direct vertical contact with other aquifers or separated by thin (< 25 feet) clay layers. Aquifers below the blue or gray clay usually consisted of fine grained sands and occasional gravels. These aquifers were confined and separated from other aquifers by clay layers with thicknesses that ranged from tens to hundreds of feet. The occurrence of blue or gray clay in the well cuttings was used to assign the well to the TVD subarea. Blue or gray clay was present in the lithologic descriptions for 94 of the 137 wells (69 percent) assigned to the TVD subarea. Wells greater than about 250 feet deep without blue or gray clay were generally assigned to the TVD subarea if they were completed in fine grained sands with significant confining pressure (flowing artesian wells and wells with water levels near the land surface). Water temperature, specific conductance and alkalinity collected through the Statewide Program were considered when confirming the original subarea designations or for re-assigning the site to the proper subarea.

Sand and gravel layers in the TVS subarea may be discontinuous and local because they are alluvial and fluvial deposits which commonly have limited areal extent. However, the lithologic section contains a low percentage of clay which means that the TVS aquifers may be connected hydrologically. Furthermore, the existence of terraces with wells completed at different depths complicates the analyses for the TVS subarea (Figure 12). Detailed stratigraphic correlations and geochemical data will be important for determining the degree of vertical and horizontal hydrological connections between TVS aquifers. Some aquifers in the TVD subarea may be more continuous than the aquifers of the TVS subarea because they are lacustrine deposits whose extents may be wider and more continuous than fluvial/alluvial deposits. Squires (1992) reported that seven wells completed in the Lake Margin Sands of Northeast Boise facies (equivalent to the TVD subarea) showed some degree of hydraulic



connection during an aquifer test. The distance between the two wells located the farthest apart was over two miles.

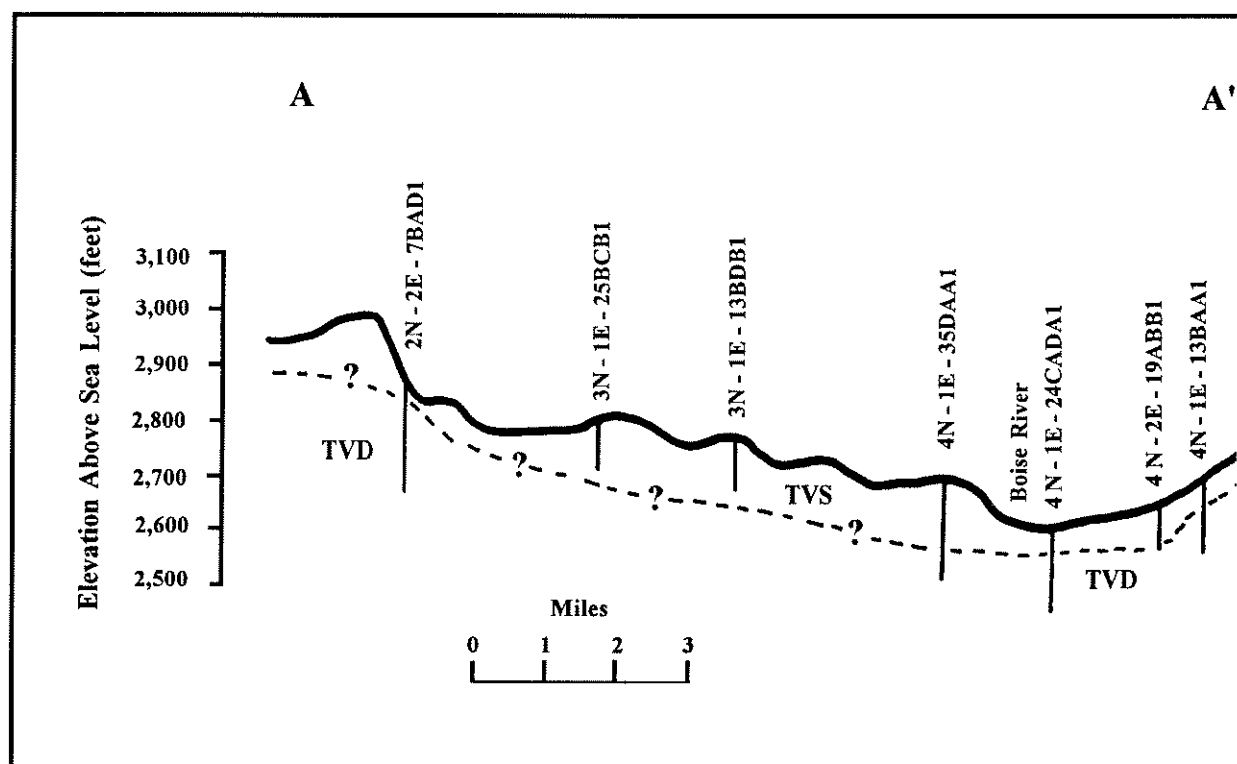


Figure 12. Stratigraphic relationships based on well log data for the Treasure Valley Shallow (TVS) and the Treasure Valley Deep (TVD) subareas. Location of the Line of Section is shown in Figure 5.

## Network Development

The number and location of monitoring sites for the Statewide Program were determined using a stratified random selection technique (Neely, 1994). The following steps describe the site selection process: 1) the state was subdivided into 22 hydrogeologic subareas based primarily on aquifer descriptions by Graham and Campbell (1981), 2) the number of sites for 20 of the 22 subareas was estimated using the Neyman maximum allocation method which incorporated weighting factors for population, aquifer area and water quality variability (Nelson and Ward, 1981; Spruill, 1990); two subareas have not been sampled because they do not have major aquifers and they have very small populations, 3) potential monitoring areas were selected randomly using the Public Land Survey System as the grid, and 4) monitoring sites were picked randomly for each selected grid from existing well and spring databases maintained by the USGS and the IDWR. Sites were required to have well construction and lithologic information, to have water temperatures less than 29.4° C (non-geothermal) and to be representative of the aquifer system in the area (which was determined by inspecting the lithologic records on the well driller's reports). Owners were contacted for permission to sample their sites.

The Statewide Program monitoring network was developed over a four-year time period due to funding and logistical reasons. About 400 new sites were added to the network annually from 1991 through 1994. The data collected during this time period is called First Round sampling. The goal of First Round sampling was to collect enough baseline data to characterize the ground water quality in the state's aquifers (Program Objective #1). Second Round sampling began in 1995 with the re-sampling of the 1991 sites and continued in 1996 and 1997 with the re-sampling of the 1992 and 1993 sites, respectively. Most sites are scheduled to be sampled once every four years. About 100 sites are being sampled annually. The goal of Second Round sampling is to provide data for trend analyses (Program Objective #2).

Currently, there are 144 Statewide Program monitoring sites in the TVS subarea (Figure 13) and 137 sites in the TVD subarea (Figure 14). Clustering of monitoring sites occurs in some areas due to the nature of the selection process. Data gaps (no sites in some areas) exist because there were no viable monitoring sites or because the random selection process did not pick these

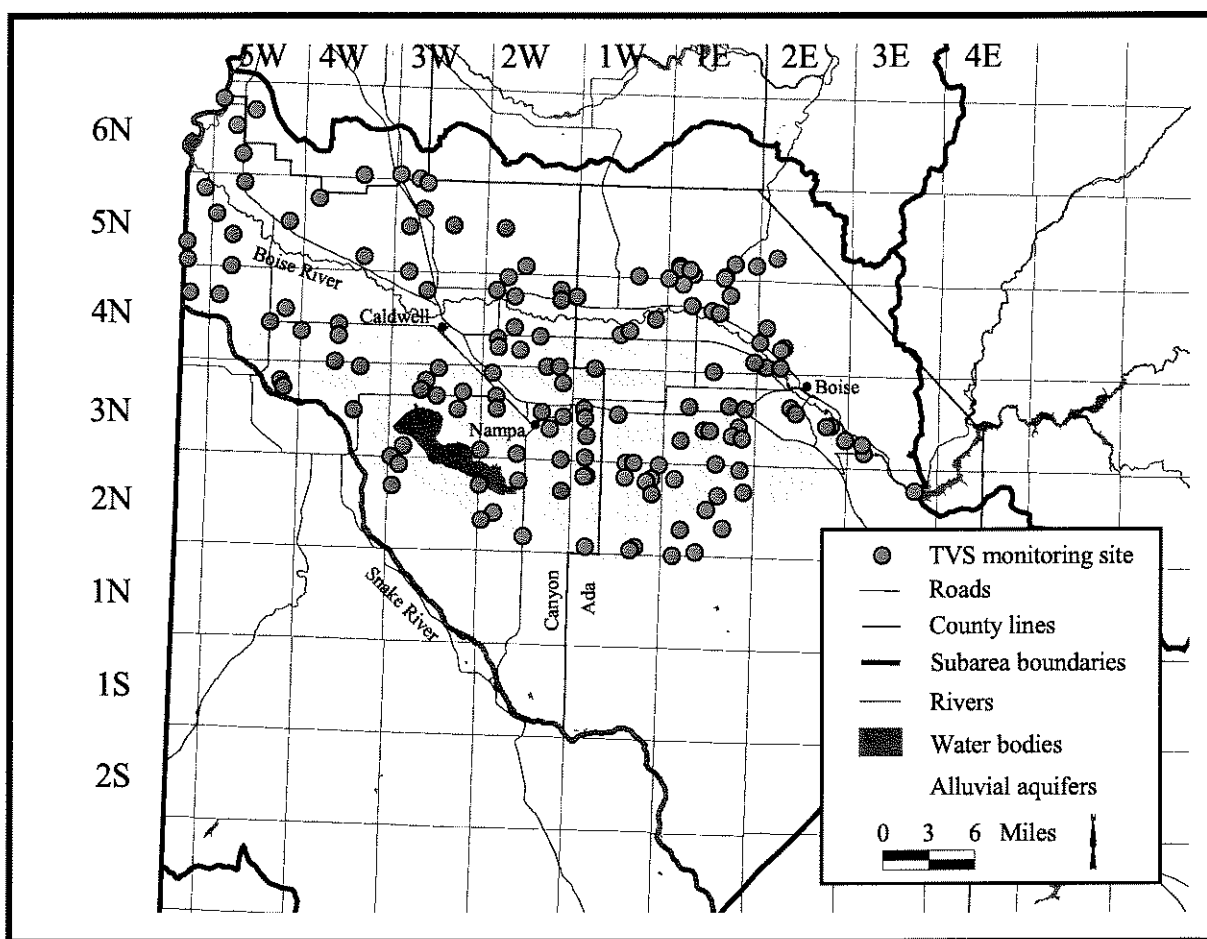


Figure 13. Statewide Program monitoring sites for the Treasure Valley Shallow (TVS) subarea.

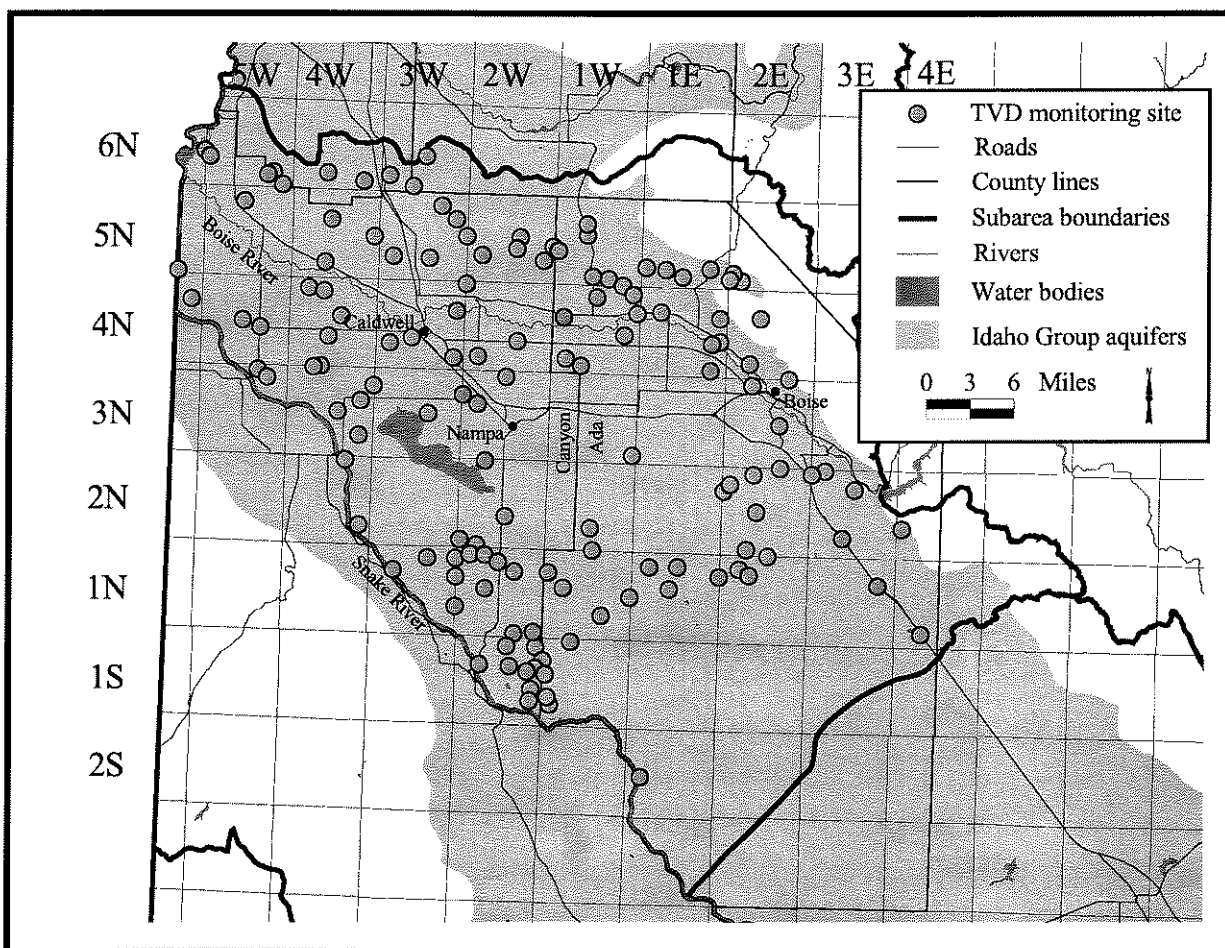


Figure 14. Statewide Program monitoring sites for the Treasure Valley Deep (TVD) subarea.

areas. The southern extent of sites in the TVS subarea is the northern border of Township 1 North which is where the pinchout of the shallow aquifer occurs (Figure 13). Monitoring sites occurred farther south in the TVD subarea because the Idaho Group aquifers have larger areal extents than the Snake River Group aquifers of the TVS subarea.

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## GROUND WATER QUALITY CHARACTERIZATION

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Characterization of the ground water quality in the TVS and TVD subareas was accomplished using Statewide Program data collected from 1991 through 1997. Characterization for this report includes general statements about constituent concentration distributions as well as basic descriptive and nonparametric statistical test results. Detailed characterization relating ground water quality to stratigraphy, land uses, etc., is not within the scope of the Statewide Program but may be addressed through regional and/or local monitoring. Primary and Secondary Maximum Contaminant Levels (MCLs) as established by the U.S. Environmental Protection Agency were used as yardsticks to assess the ground water quality. Primary MCLs apply to constituents with potential human health concerns; secondary MCLs are used for aesthetic properties of the water. Primary and Secondary MCLs were adopted as Idaho Ground Water Quality Rules in 1996 (IDAPA 16.01.11.400.03).

Characterization results are discussed in the following sections: 1) network design verification, 2) well parameters and field measurements, 3) major ions, 4) nutrients, 5), trace elements, 6) radioactivity, 7) volatile organic compounds, 8) pesticides, 9) bacteria, and 10) characterization summary.

### Network Design Verification

Ideally, it would have been desirable to sample all of the selected network sites in one year. However, this approach was not economically or logistically possible. Therefore, the network development occurred over four years from 1991 through 1994 which is the time period called First Round sampling. Statistical tests were conducted to determine if the data collected annually during First Round sampling could be combined and treated as single datasets (i.e., one dataset for the TVS subarea and one dataset for the TVD subarea). Data from Second Round sampling (1995 through 1997) were not used for network design verification because these data are re-samples of the 1991 through 1993 sites, respectively.

The Kruskal-Wallis and the Mann-Whitney rank-sum statistical tests (both non-parametric) were selected because most of the data had skewed distributions as indicated by distribution curves and by skewness coefficients greater than 2.0. The Kruskal-Wallis test can determine if  $k$  groups ( $k > 2$ ) have identical distributions or if at least one group differs in its distribution (Helsel and Hirsch, 1992). If a Kruskal-Wallis test indicates that at least one group has a different distribution than the other groups, the Mann-Whitney rank-sum test can be used to determine which group(s) has the different distribution. The Mann-Whitney rank-sum test is used to test two groups at a time to determine if one group is producing larger observations than the other group (Helsel and Hirsch, 1992). Each test produces a test statistic and an associated

probability (p) value. There is a significant difference between the groups tested at the 95 percent confidence level if the p value is equal to or less than 0.05. There is no significant difference between the groups tested at the 95 percent confidence level if the p value is greater than 0.05. See Appendix D for a description of the statistical tests used in this report.

Tests were conducted on 20 constituents and parameters selected because they had concentrations greater than the laboratory method detection limit. Separate tests were run on each constituent and parameter. For example: the Kruskal-Wallis test was run on the nitrate data for the four annual data subsets (1991 through 1994) for the TVS subarea. The results indicated that at least one subset (year) was significantly different than the other subsets. Mann-Whitney rank-sum tests were conducted on two subsets at a time (1991 versus 1992, 1991 versus 1993, etc.). Results from the Mann-Whitney rank-sum tests indicated that the nitrate data for the TVS subarea for 1991 was significantly different than the nitrate data for 1994 at the 95 percent confidence level (see further discussion in Nutrients section).

Kruskal-Wallis test results for the TVS subarea indicated that there were no significant differences in median concentrations at the 95 percent confidence level for 17 of the 20 parameters and constituents (85 percent). The constituents with significant differences were pH, nitrate and ammonia. Nitrate and ammonia differences were probably anthropogenic and not due to the statistical sampling technique. Mann-Whitney rank-sum test results for pH, nitrate and ammonia are discussed in the Well Parameters and Field Measurements section and in the Nutrients section.

Kruskal-Wallis test results for the TVD subarea showed that there were no significant differences in median concentrations at the 95 percent confidence level for any of the 20 constituents and parameters.

The results from the statistical tests for the TVS and TVD subareas indicated that the constituents from the annual data subsets for 1991 through 1994 could be combined into single datasets for each subarea.

## **Well Parameters and Field Measurements**

Well parameters discussed in this section include well depth and casing openings. Field measurements recorded as part of the Statewide Program were temperature, pH, specific conductance and alkalinity.

Well depths for the TVS subarea monitoring sites ranged from 29 to 362 feet with the median depth being 100 feet. Well depths varied throughout the subarea but, in general, wells were deeper in the southern areas (Figure 15). Wells completed in the TVS subarea were typically cased to the total drill depth with the openings usually at or near the bottom of the

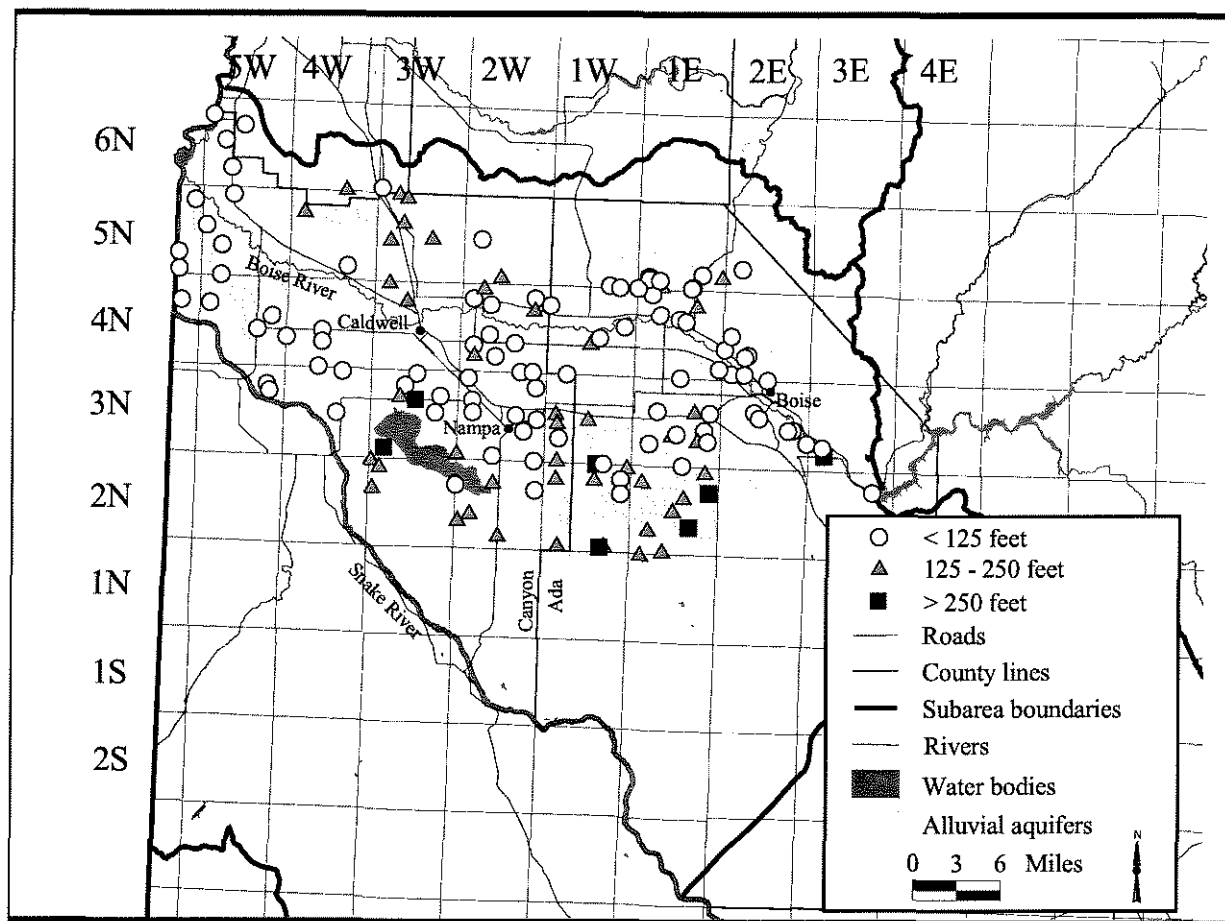


Figure 15. Well depths for TVS subarea monitoring sites.

casing. Some wells were perforated in several sand and gravel layers. The few wells completed in basalt aquifers usually were cased only in the upper section of the hole above the basalt.

Ground water temperatures for the TVS subarea ranged from  $11.1^{\circ}$  to  $25.0^{\circ}$  C with the median temperature being  $13.9^{\circ}$  C. The warmer ground water temperatures ( $15.0$  to  $20.0^{\circ}$  C) occurred in the western, southern and northeastern parts of the TVS monitoring network (Figure 16). Two sites had ground water temperatures greater than  $20.0^{\circ}$  C.

Well depths in the TVD subarea monitoring sites ranged from 44 to 1001 feet with the median depth being 325 feet. The deepest wells were located in the southeastern and southcentral parts of the subarea (Figure 17). Wells in the TVD subarea were typically cased to the total drill depth with multiple openings (either screened or perforated).

Ground water temperatures for the TVD subarea ranged from  $12.8^{\circ}$  to  $32.0^{\circ}$  C with the median temperature being  $18.9^{\circ}$  C. One well that had a geothermal water temperature ( $31.7^{\circ}$  C) was included in the TVD network because it was representative of the local drinking water

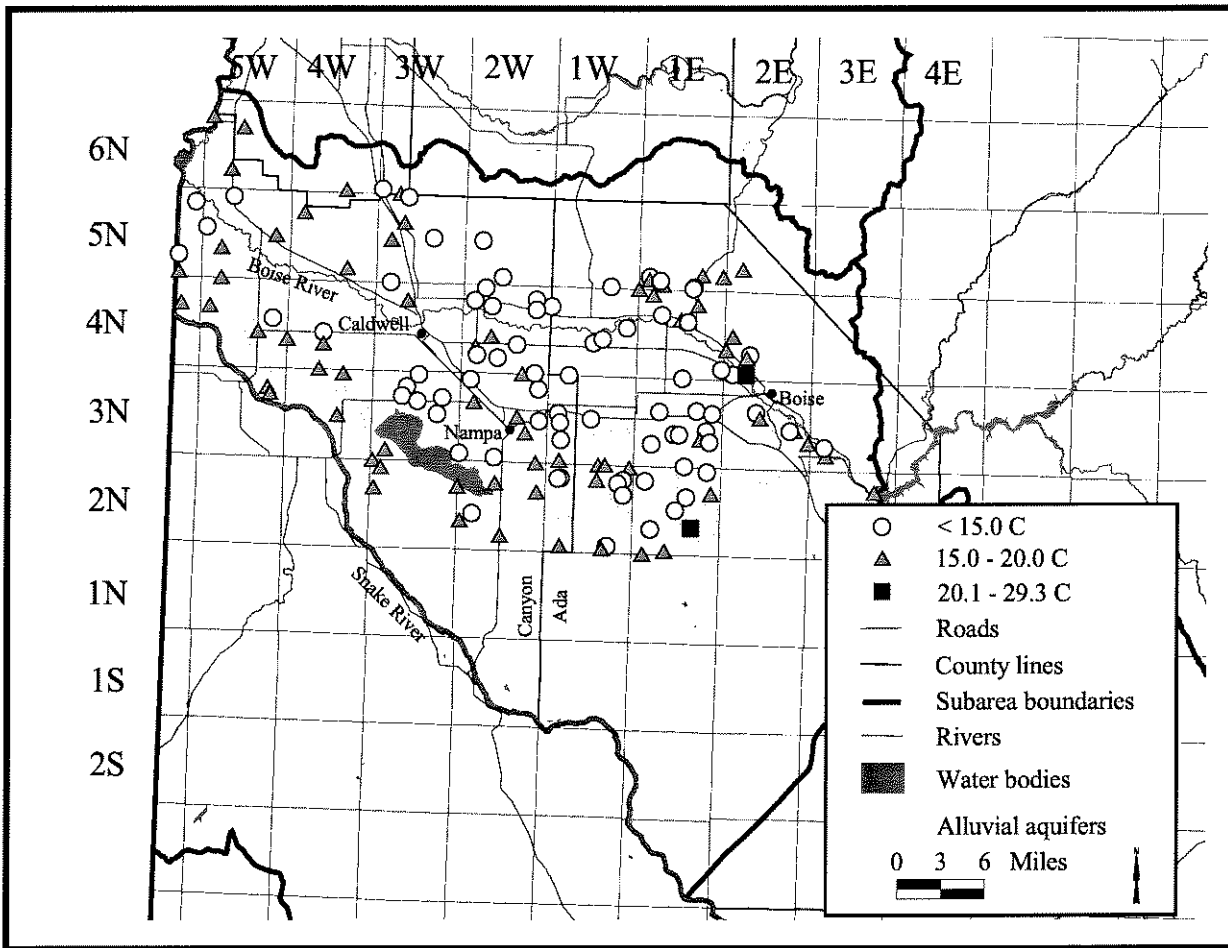


Figure 16. Ground water temperatures for TVS subarea monitoring sites, 1991-1994.

supply and was being used as a drinking water supply. Ground water temperatures greater than  $20.0^{\circ}\text{C}$  were more common in the southern part of the subarea than in the other areas (Figure 18).

Water quality data were examined using scatterplots to determine if any visual relationships were apparent. The locally weighted scatterplot smoothing (LOWESS) method was used to add a curve to each scatterplot to show the general middle trend of the data (Helsel and Hirsch, 1992). The Spearman's rho rank-order nonparametric test was performed on two water quality variables at a time to measure the correlation coefficient (i.e., the strength of the association) between the variables (Helsel and Hirsch, 1992). Correlation coefficients can range from -1 to 1 using the Spearman's rho test. Correlation coefficients near zero indicate no correlation between the two variables tested. Positive correlation coefficients indicate that as one variable increases, the other variable increases too. Negative correlation coefficients indicate that as one variable increases, the other variable decreases. A probability (p) can be calculated for each correlation coefficient. When p is equal to or less than 0.05, the relationship



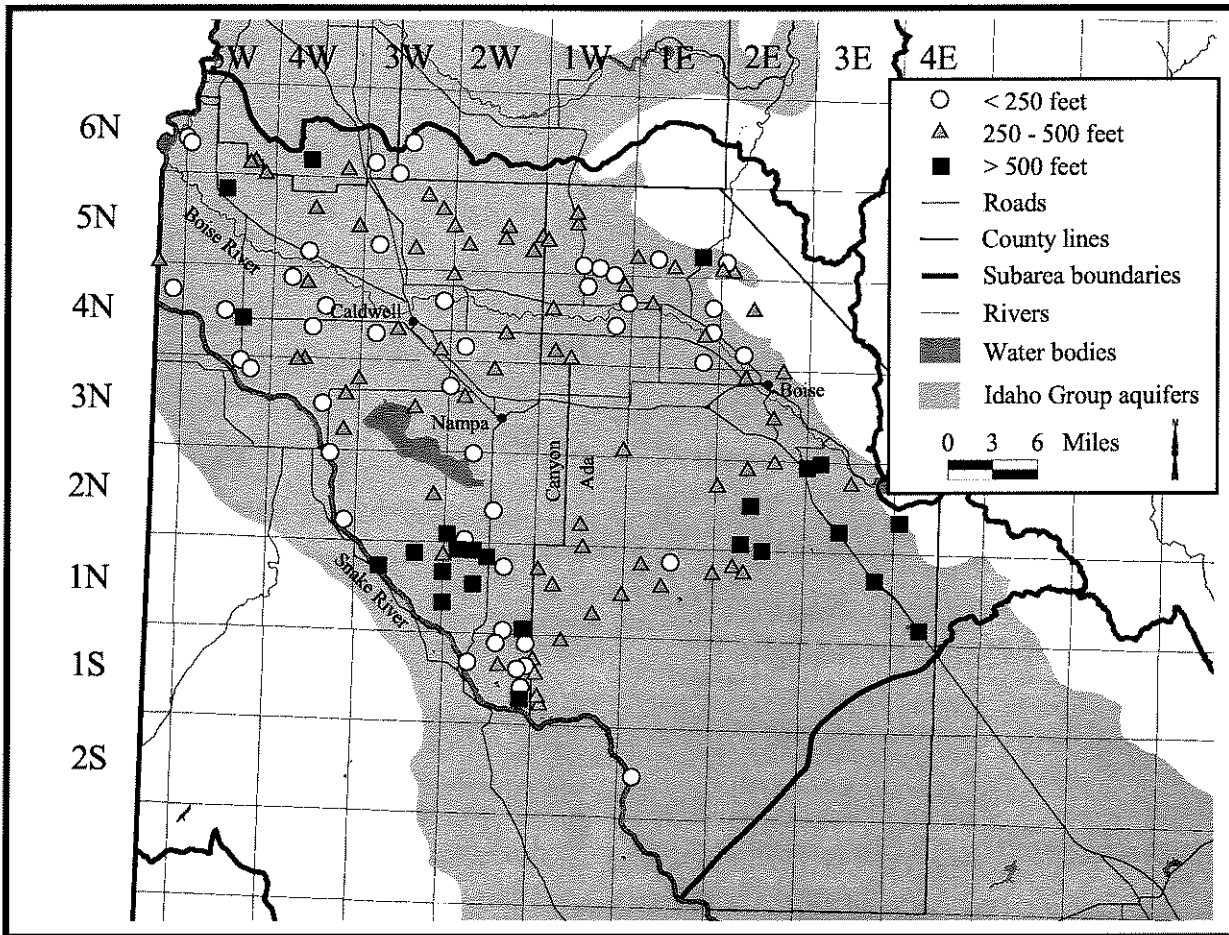


Figure 17. Well depths for TVD subarea monitoring sites.

between the two variables is significant at the 95 percent confidence level.

Significant relationships existed at the 95 percent confidence level between well depth and the four field parameters (temperature, pH, specific conductance and alkalinity). Temperature and pH increased as well depth increased (Figures 19 and 20); specific conductance and alkalinity decreased with increasing well depth (Figures 21 and 22).

Boxplots of field parameters versus subarea designation showed that there were differences in concentration medians and ranges between the two subareas (Figure 23). Mann-Whitney rank-sum tests indicated that temperature and pH medians for the TVD subarea were significantly higher at the 95 percent confidence level while specific conductance and alkalinity medians were significantly higher for the TVS subarea (Table 2). Mann-Whitney rank-sum tests also indicated that the median pH concentration for the TVS subarea for 1991 was significantly higher at the 95 percent confidence level than the median pH values for the TVS subarea for 1992 and 1993. The reason for these differences is unknown.

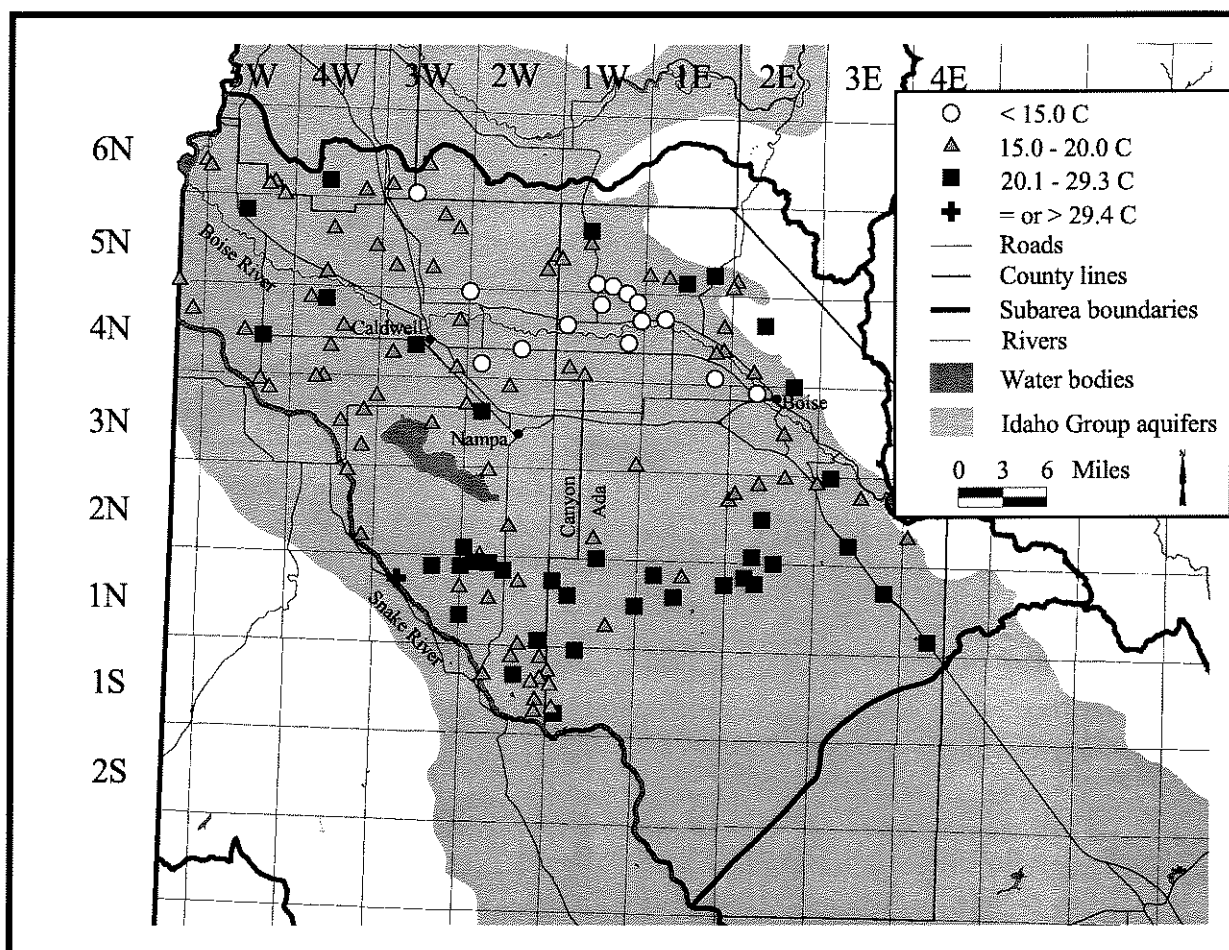


Figure 18. Ground water temperatures for TVD subarea monitoring sites, 1991-1994.

## Major Ions

Major ions analyzed were calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, nitrate and fluoride. Total dissolved solids (calculated from major ion concentrations) and hardness (calculated from calcium and magnesium) were also analyzed.

Trilinear plotting indicated that there were differences in water chemistry between subareas and within each subarea. The water chemistry for the TVD subarea was more variable than the chemistry for the TVS subarea as indicated by the quadrilateral (diamond-shape) plots (Figures 24 and 25). Most water types in the TVS subarea were calcium-bicarbonate. Water types in the TVD subarea ranged from calcium-bicarbonate to sodium-bicarbonate. Bicarbonate was the dominant anion where TDS values were lowest. Chloride and sulfate were the dominant anions only in the ground waters with the highest TDS concentrations.

Table 2. Results of Mann-Whitney rank-sum tests for selected constituents and parameters versus subarea designation.

Constituent/Parameter	Was there a significant difference in medians between the TVS and TVD subareas at the 95 % confidence level?	Subarea with the higher median value
Temperature	Yes	TVD
pH	Yes	TVD
Specific conductance	Yes	TVS
Alkalinity	Yes	TVS
Calcium	Yes	TVS
Magnesium	Yes	TVS
Sodium	Yes	TVS
Potassium	No	
Bicarbonate	Yes	TVS
Sulfate	Yes	TVS
Chloride	No	
Nitrate	Yes	TVS
Fluoride	No	
TDS	Yes	TVS
Hardness	Yes	TVS
Ammonia	Yes	TVD
Iron	Yes	TVD
Manganese	Yes	TVD
Arsenic	No	
Gross alpha	Yes	TVS
Gross beta	Yes	TVS
Radon	Yes	TVS

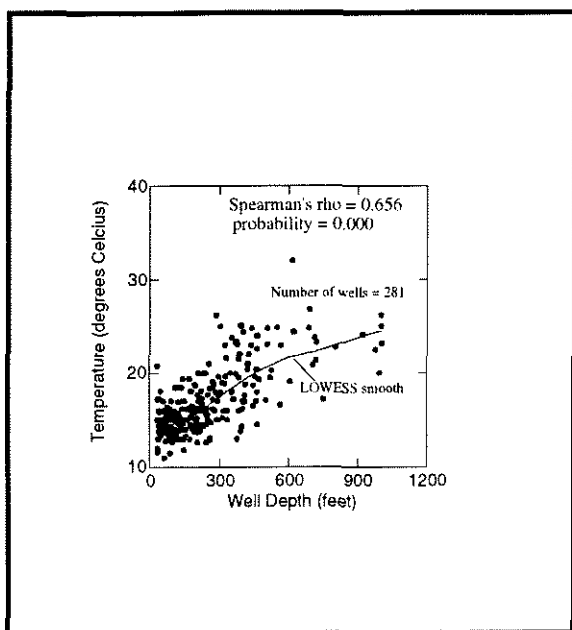


Figure 19. Scatterplot and Spearman's rho test results for temperature versus well depth for TVS and TVD monitoring sites, 1991-1994.

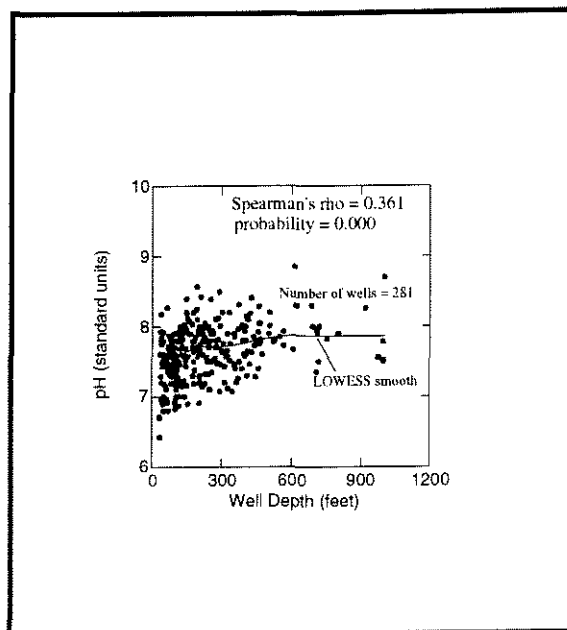


Figure 20. Scatterplot and Spearman's rho test results for pH versus well depth for TVS and TVD monitoring sites, 1991-1994.

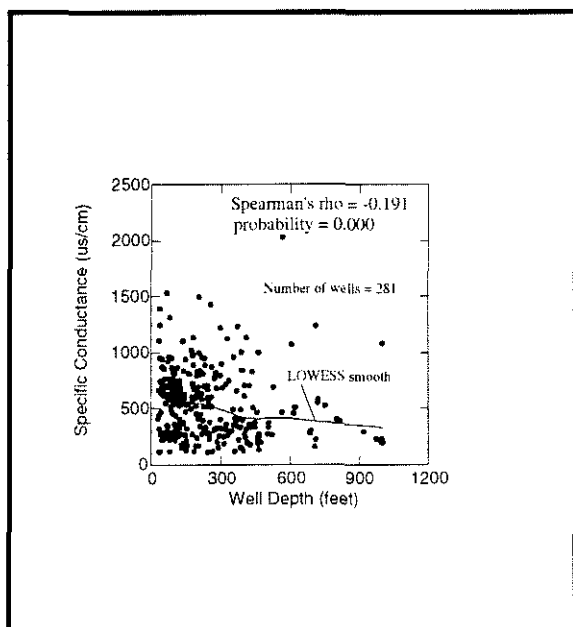


Figure 21. Scatterplot and Spearman's rho test results for specific conductance versus well depth for TVS and TVD monitoring sites, 1991-1994.

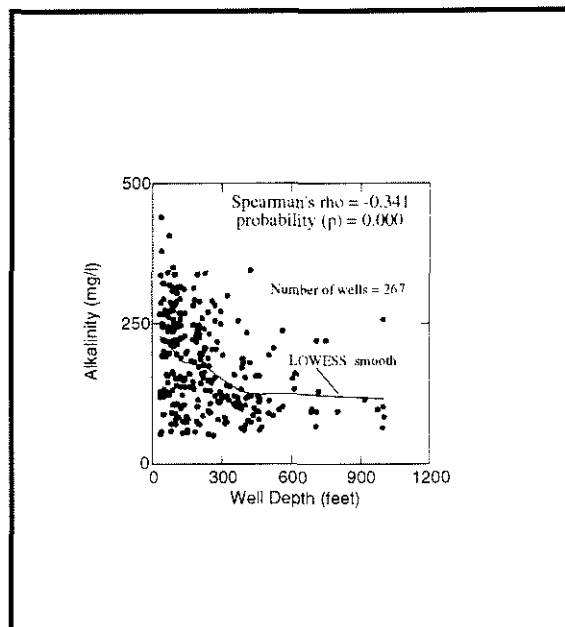


Figure 22. Scatterplot and Spearman's rho test results for alkalinity versus well depth for TVS and TVD monitoring sites, 1991-1994.

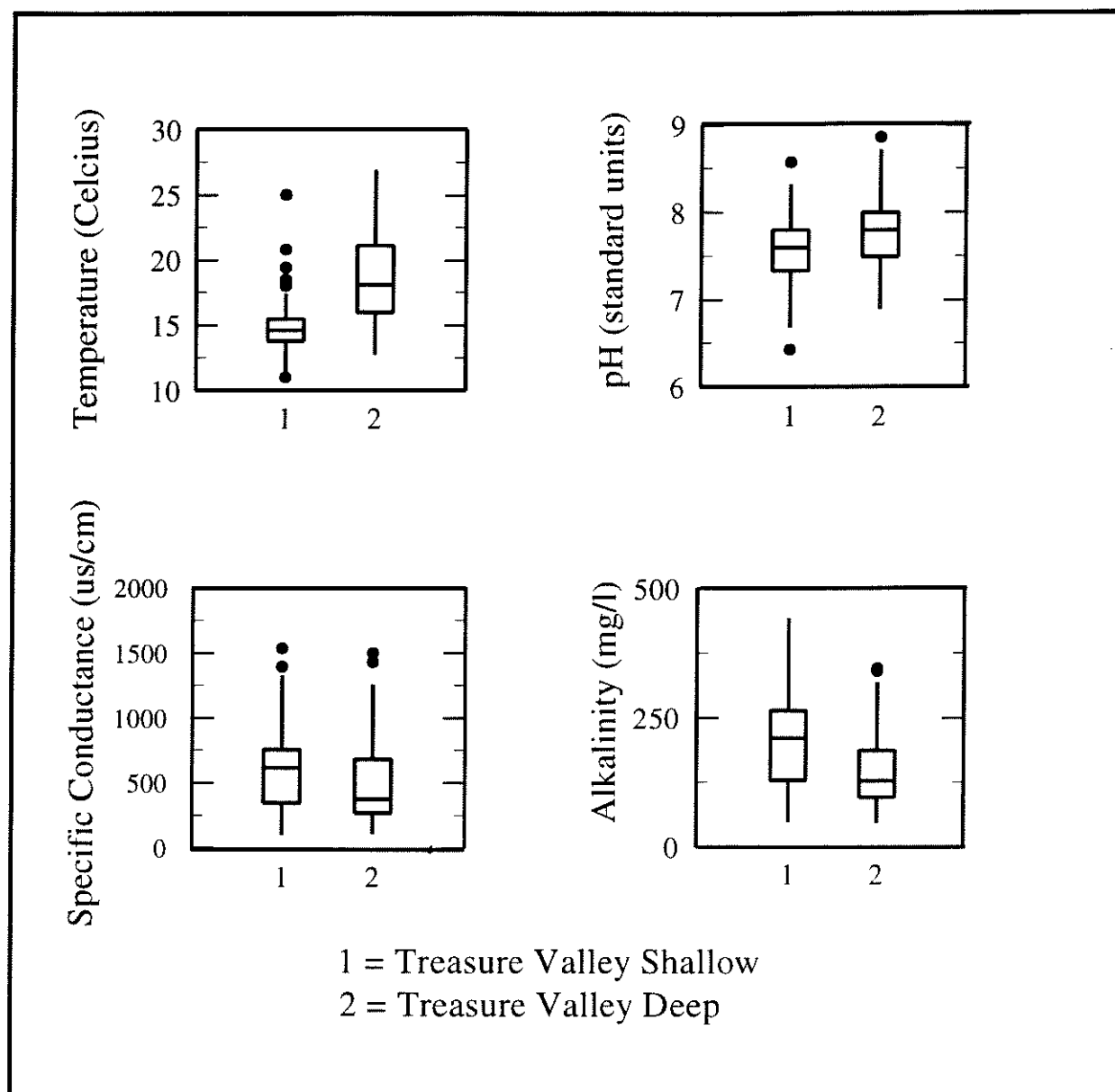


Figure 23. Boxplots for field parameters versus subarea designation for Treasure Valley monitoring sites, 1991-1994.

Total Dissolved Solids (TDS) concentrations for the TVS subarea ranged from 82 to 956 mg/l with the median being 392 mg/l. TDS concentrations exceeded the secondary MCL of 500 mg/l at 34 of the 144 (24 percent) TVS sites. TDS concentrations were generally higher in the southcentral and western parts of the subarea (Figure 27). The median TDS value for the TVS subarea was significantly higher at the 95 percent confidence level than the median TDS value for the TVD subarea (Figure 28 and Table 2). Patterns of occurrence for the common ions were not predictable; some ions had high concentrations in the same general areas as the higher TDS values while other ions showed no discernible patterns. The range of TDS concentrations for

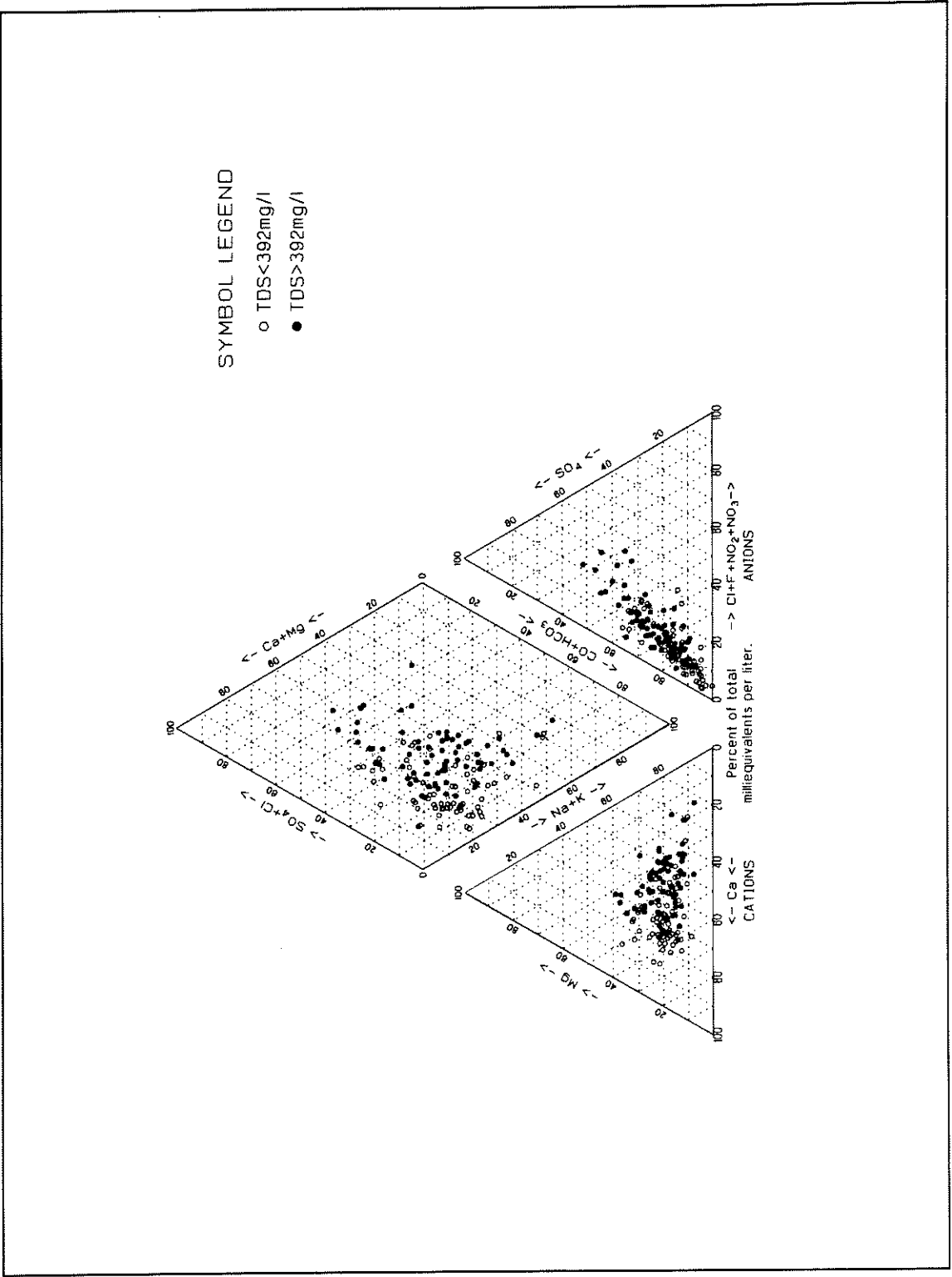


Figure 24. Trilinear diagram plot for the Treasure Valley Shallow subarea, 1991-1994. Median TDS concentration equaled 392 mg/l.

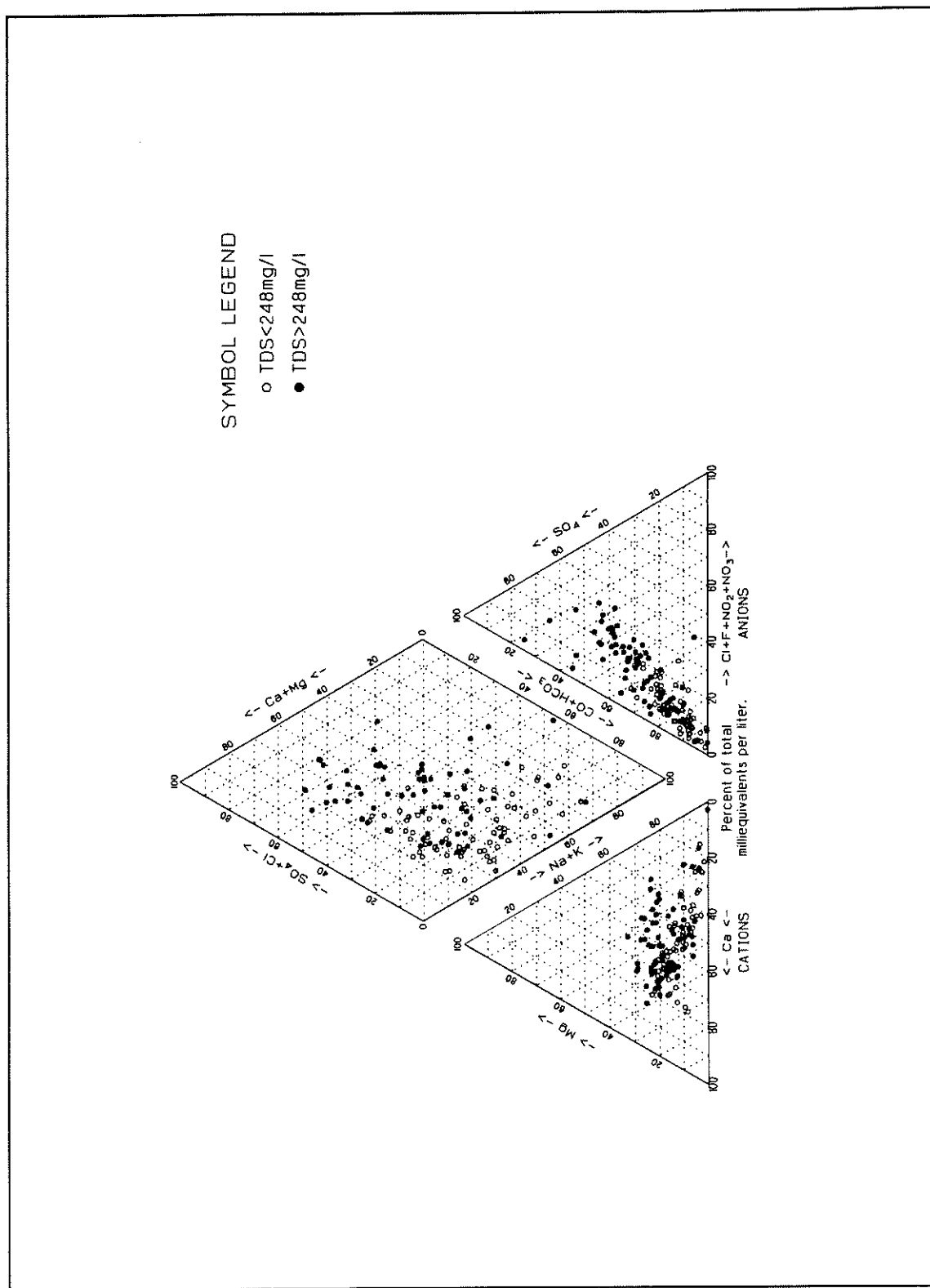


Figure 25. Trilinear diagram plot for the Treasure Valley Deep subarea, 1991-1994. Median TDS concentration equaled 248 mg/l.

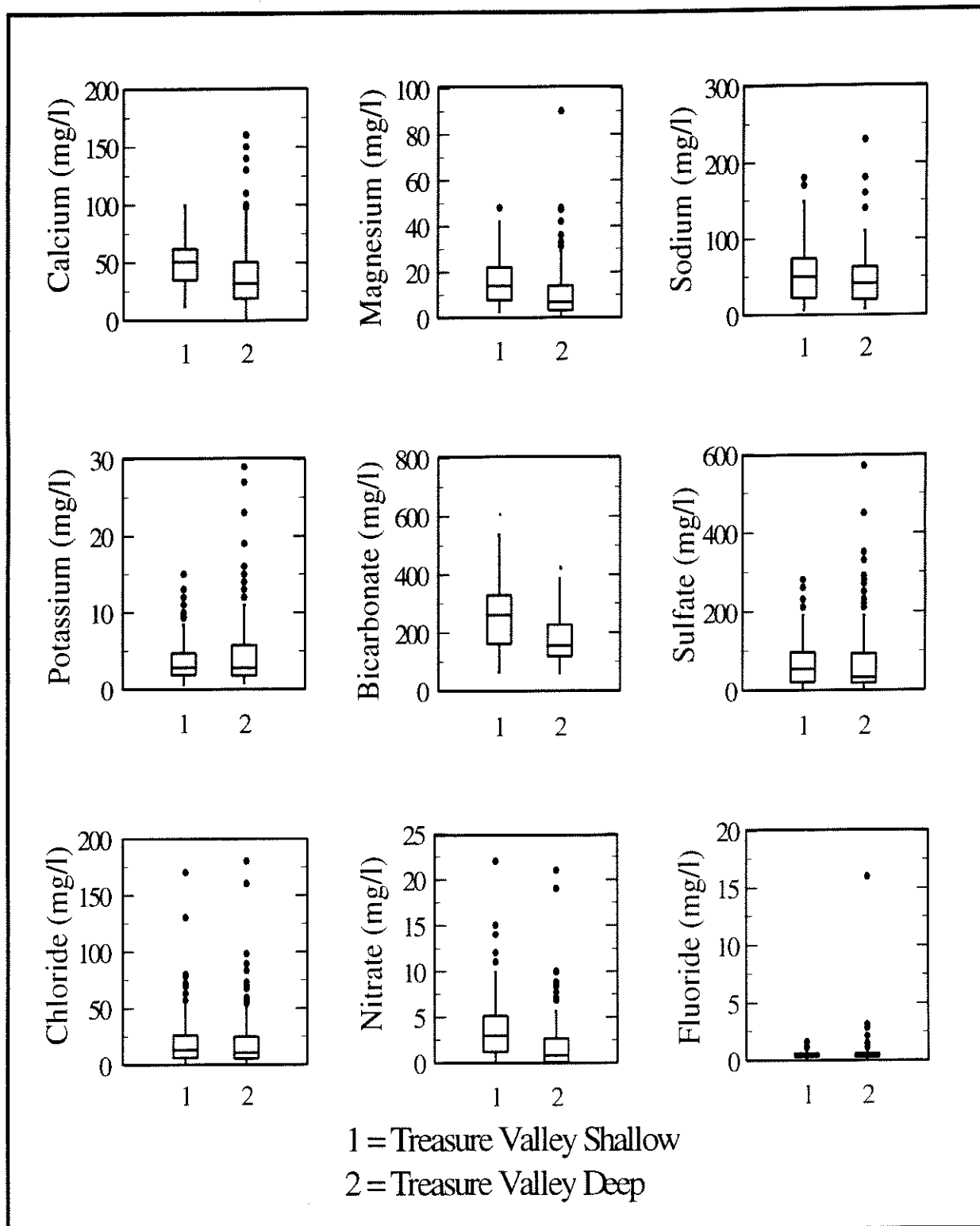


Figure 26. Boxplots for major ions versus subarea designation for Treasure Valley monitoring sites, 1991-1994.



samples collected from surface water in the Treasure Valley (Thomas and Dion, 1974) was generally lower than the range of TDS concentrations for the TVS subarea monitoring sites.

Hardness values for the TVS subarea ranged from 41 to 417 mg/l with the median being 189 mg/l. One hundred of the 144 TVS sites (69 percent) had "hard" (151 to 300 mg/l) or "very hard" (greater than 300 mg/l) water. The median hardness value for the TVS subarea was significantly higher at the 95 percent confidence level than the median for the TVD subarea (Figure 29 and Table 2). Soft (less than 75 mg/l) and moderately hard (75 to 150 mg/l) ground waters were found in sites near the Boise River and in an area southwest of Boise (Figure 30).

TDS concentrations for the TVD subarea ranged from 88 to 1,370 mg/l with the median being 248 mg/l. The highest TDS concentrations were found distinctly in the southern and western parts of the subarea (Figure 31). TDS concentrations were greater than the secondary MCL of 500 mg/l at 24 of the 137 TVD sites (18 percent). The higher concentrations for calcium, magnesium, potassium, sodium, sulfate, chloride and bicarbonate all occurred in the same general areas as the higher TDS concentrations.

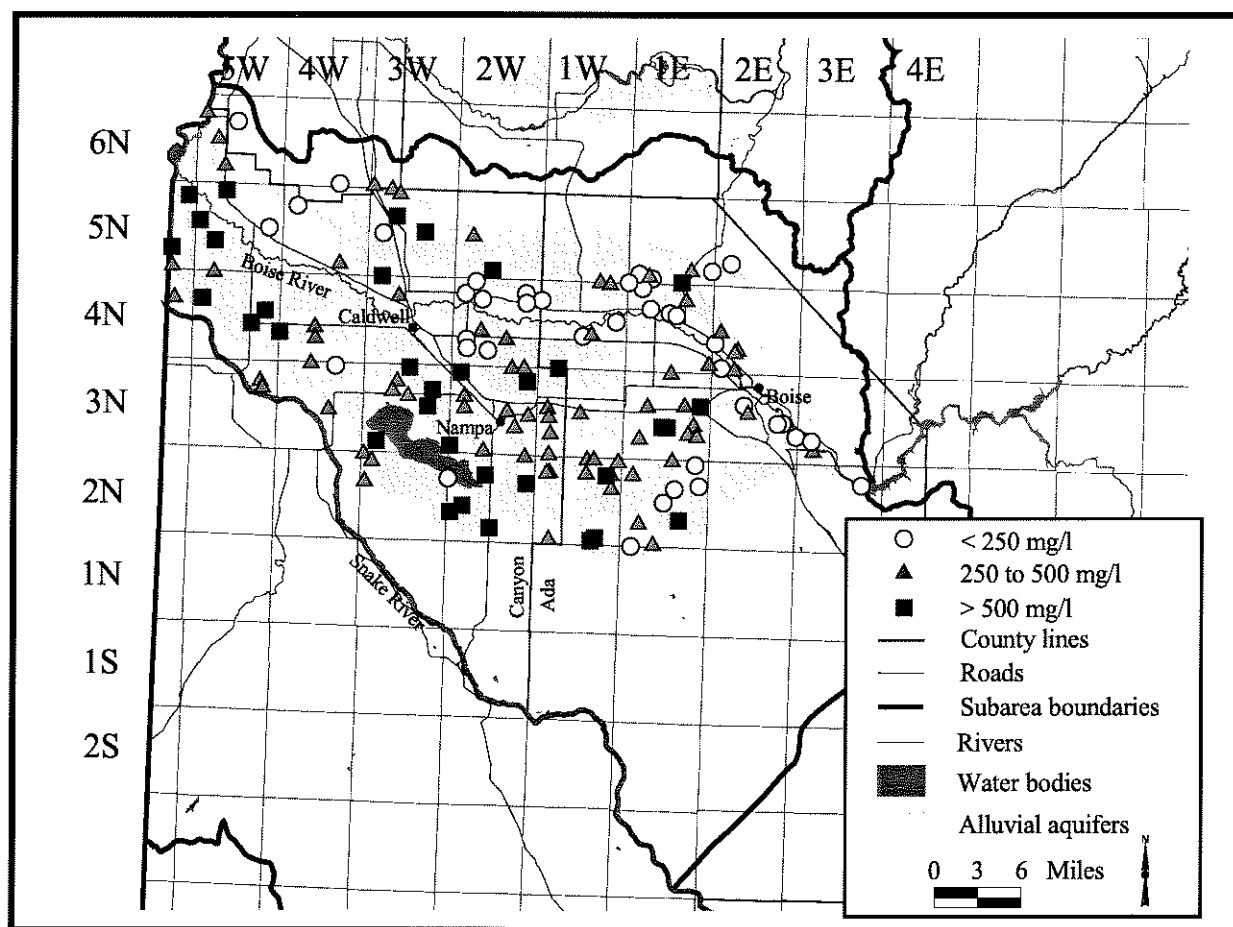


Figure 27. TDS concentrations for the Treasure Valley Shallow subarea, 1991-1994.

Hardness values for the TVD subarea ranged from 22 to 720 mg/l with the median being 114 mg/l. Ninety-one of the 137 TVD sites (66 percent) had "soft" or "moderately hard" water. The highest hardness values were found in the southcentral and western parts of the subarea (Figure 32).

Spearman's rho tests indicated that significant negative relationships existed between well depth and TDS ( $\rho = -0.188$ ; probability = 0.000) and between well depth and hardness ( $\rho = -0.287$ ; probability = 0.000) for the Treasure Valley monitoring sites. The test results revealed that as well depth increased, TDS and hardness concentrations decreased. However, there is an area south of Nampa where the highest TDS concentrations were associated with the deepest wells.

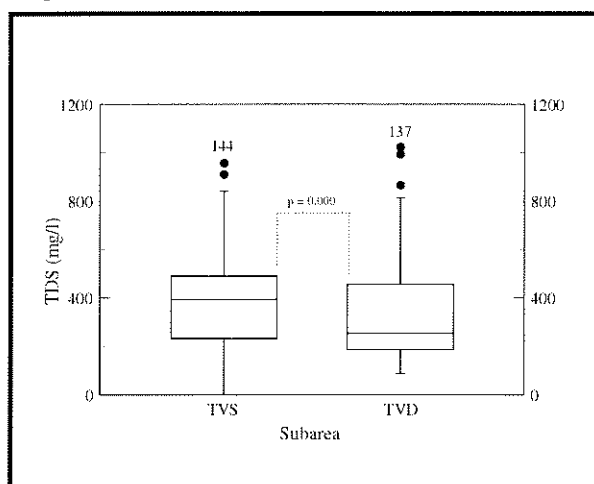


Figure 28. Boxplots and Mann-Whitney rank-sum test results for TDS versus subarea designation for the Treasure Valley monitoring sites, 1991-1994.

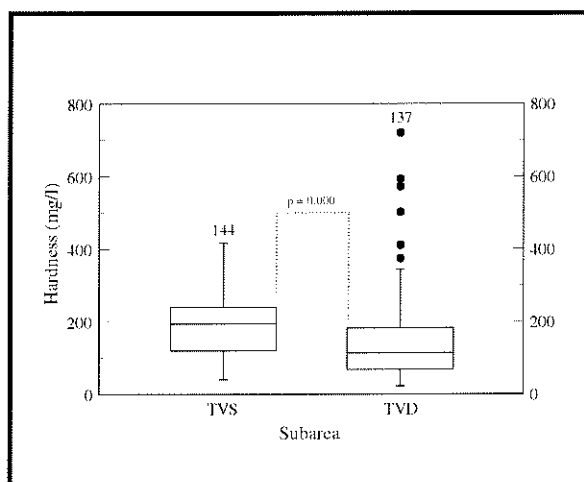


Figure 29. Boxplots and Mann-Whitney rank-sum test results for hardness versus subarea designation for the Treasure Valley monitoring sites, 1991-1994.

## Nutrients

Dissolved nitrate concentrations ( $\text{NO}_2 + \text{NO}_3$  as nitrogen) for the TVS subarea for 1991 through 1994 ranged from less than the detection limit of 0.05 mg/l at 4 sites to 22.0 mg/l with the median being 2.90 mg/l. Six of the 144 TVS sites (four percent) had nitrate values greater than the public drinking water MCL of 10 mg/l. Eighty-nine other sites (62 percent) had nitrate concentrations between 2.0 and 10.0 mg/l (Figure 33). Nitrate concentrations of 2.0 mg/l and higher are considered to be an indication that the ground water quality has been impacted by land use activities (Crockett, 1995). The median nitrate concentration was significantly higher for the TVS subarea than the median for the TVD subarea (Figure 34).

Nitrate concentrations were generally higher south of the Boise River where 75 percent of the sites had nitrate concentrations that were equal to or greater than 2.0 mg/l (Figure 35). Forty-three percent of the sites north of the Boise River had nitrate values equal to or greater

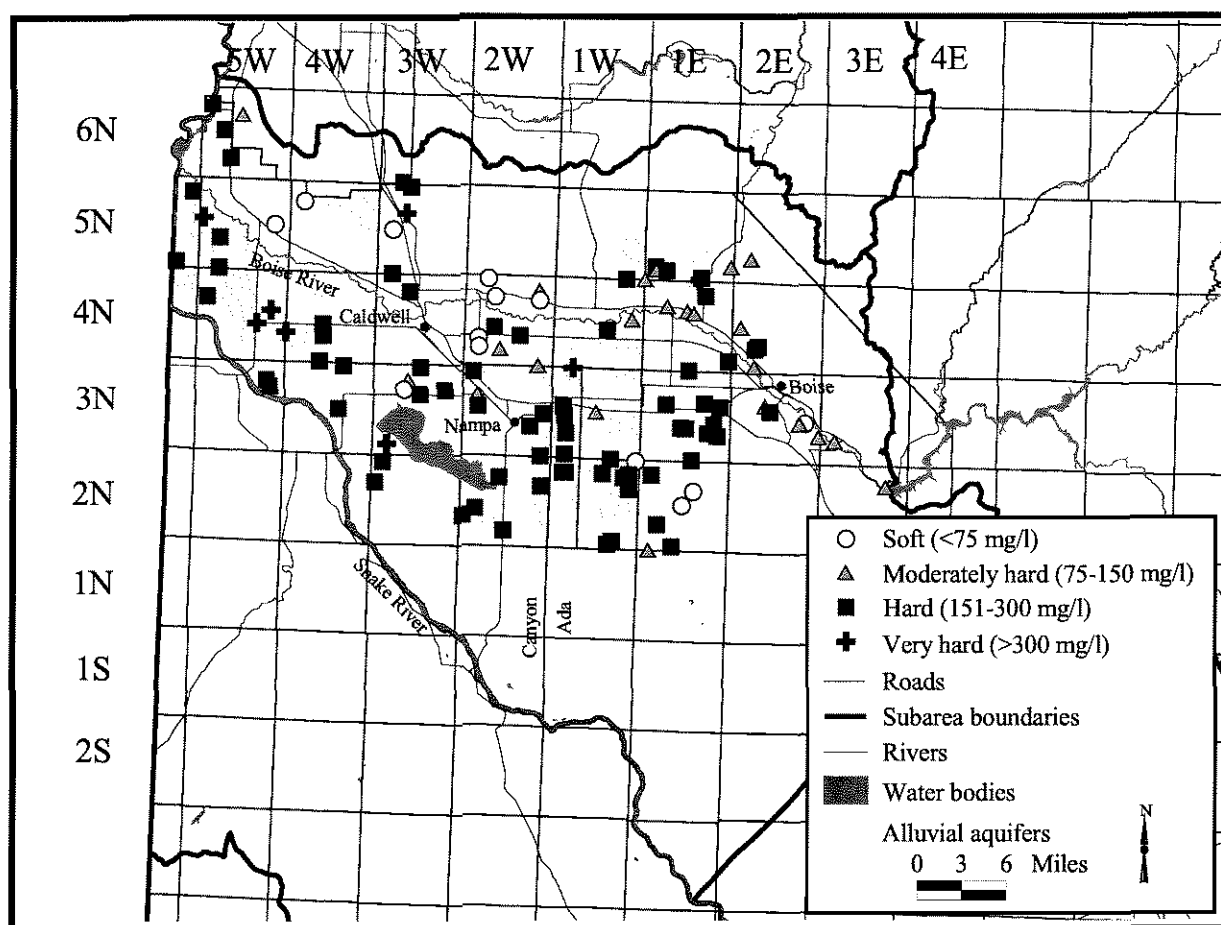


Figure 30. Hardness concentrations for the Treasure Valley Shallow subarea, 1991-1994.

than 2.0 mg/l. Four of the six sites with nitrate concentrations greater than the MCL were on the south side of the Boise River.

Comparing nitrate concentrations to land use categories revealed that sites located in the agriculture land use category had a higher median nitrate value (3.70 mg/l) than those sites in the rangeland/barren land (3.40 mg/l), farmstead/rural (3.00 mg/l) and urban (1.95 mg/l). However, only agriculture and urban categories had a significant difference in the median nitrate concentrations at the 95 percent confidence level as indicated by Mann-Whitney rank-sum tests (Figure 36). The ratio of TVS sites with impacted nitrate concentrations (equal to or greater than 2.0 mg/l) to TVS sites with non-impacted nitrate concentrations (less than 2.0 mg/l) is higher for the agriculture land use category than for the farmstead/rural and urban land use categories (Figure 37); range and barren land categories have too few sites for analyses.

Nitrate concentrations were compared to ground water vulnerability (GWV) categories as mapped by Rupert and others (1991). The High GWV category had the highest nitrate median

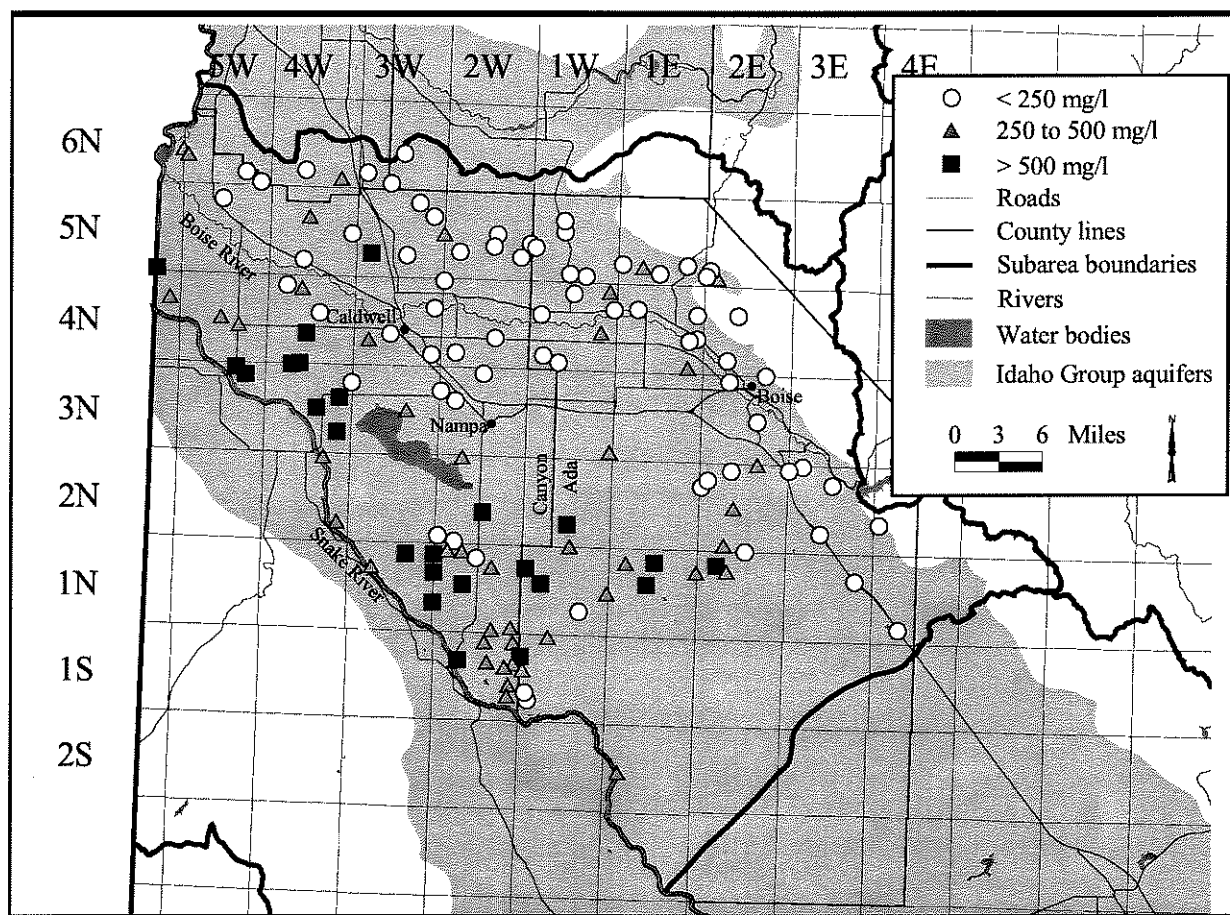


Figure 31. TDS concentrations for the Treasure Valley Deep subarea, 1991-1994.

while the Very High GWV category had the lowest median. This unexplainable observation confirms the need for calibrating GWV categories as mentioned earlier.

Dissolved ammonia concentrations for the TVS subarea ranged from less than the detection limit of 0.01 mg/l at 53 sites to 2.60 mg/l with the median being 0.01 mg/l. Two of the 144 TVS subarea sites had elevated ammonia concentrations equal to or greater than 1.0 mg/l (Figure 38); the other 142 sites had ammonia results less than 0.4 mg/l.

Dissolved orthophosphorus concentrations for the TVS subarea ranged from less than the detection limit of 0.01 mg/l at 16 sites to 1.6 mg/l. The median phosphorus concentration was 0.04 mg/l. Although phosphorus concentrations were low, they still may adversely affect surface water quality in areas of ground water discharge (Rupert, 1997b). A total phosphorus concentration of 0.1 mg/l is considered the upper limit for preventing nuisance growths of algae and plants in moving surface waters; the limit for standing water bodies can be as low as 0.05 mg/l if adequate nitrogen (greater than 0.3 mg/l of inorganic nitrogen) is present (Mackenthun, 1969). Thirty-nine of the 281 TVS and TVD monitoring sites (14 percent) had phosphorus

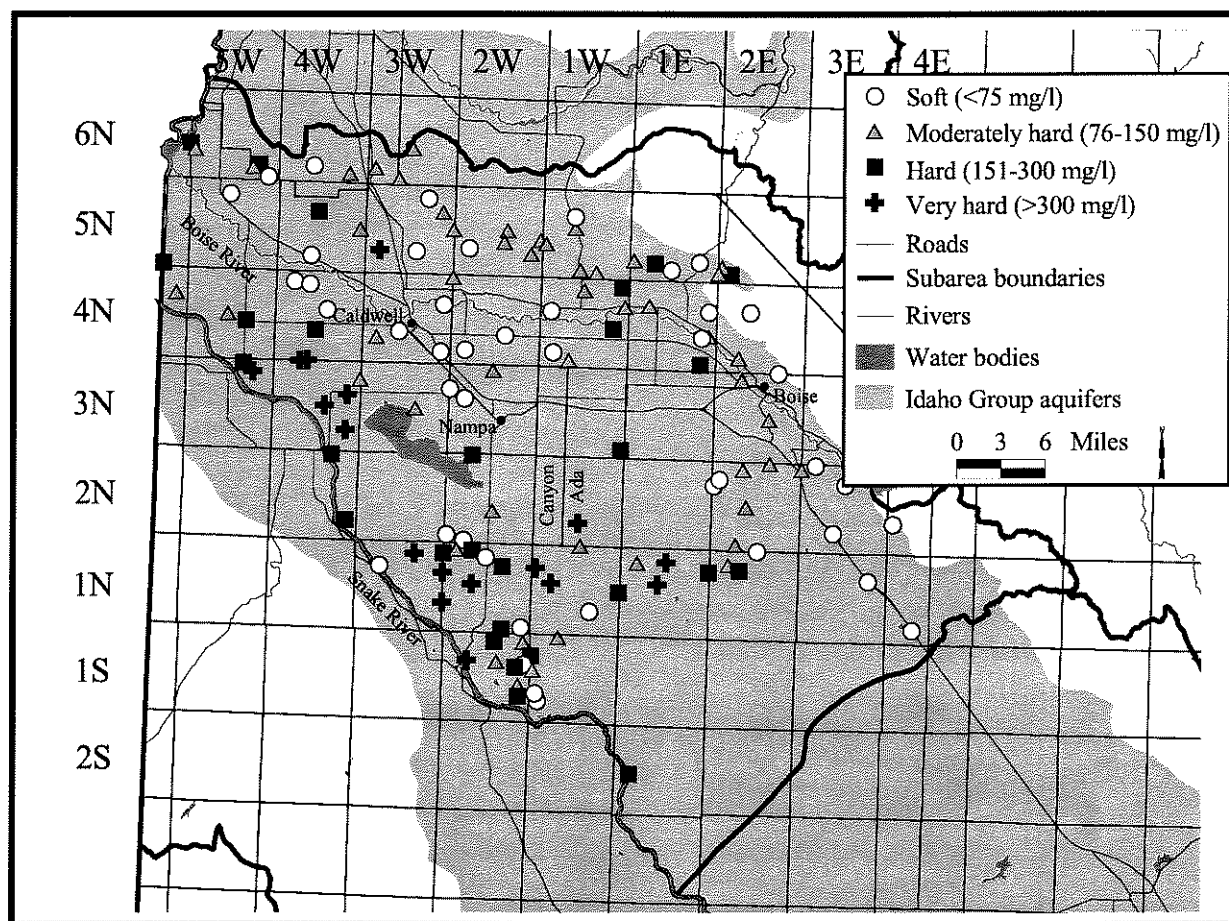


Figure 32. Hardness concentrations for the Treasure Valley Deep subarea, 1991-1994.

concentrations that were equal to or greater than 0.1 mg/l. A high percentage of these 39 sites occurred in the northeastern part of the Treasure Valley (Figure 39). Twenty-eight of the 39 sites were in the TVS subarea.

Dissolved nitrate concentrations for the TVD subarea sites ranged from less than the detection limit of 0.05 mg/l at 29 sites to 21.0 mg/l with a median of 0.81 mg/l. Two of the 137 TVD sites (one percent) had nitrate concentrations greater than 10 mg/l and 39 sites (28 percent) had nitrate concentrations between 2.0 mg/l and 10.0 mg/l (Figure 33). Nitrate concentrations were generally higher south of the Boise River (Figure 40). The percentages of sites with nitrate concentrations equal to or greater than 2.0 mg/l on the north and south sides of the Boise River were 22 and 40, respectively.

Dissolved ammonia concentrations for the TVD subarea ranged from less than the detection limit of 0.01 mg/l at 41 sites to 5.80 mg/l with a median value of 0.02 mg/l. Fourteen of the 137 TVD subarea sites (10 percent) had ammonia results equal to or greater than 1.0 mg/l

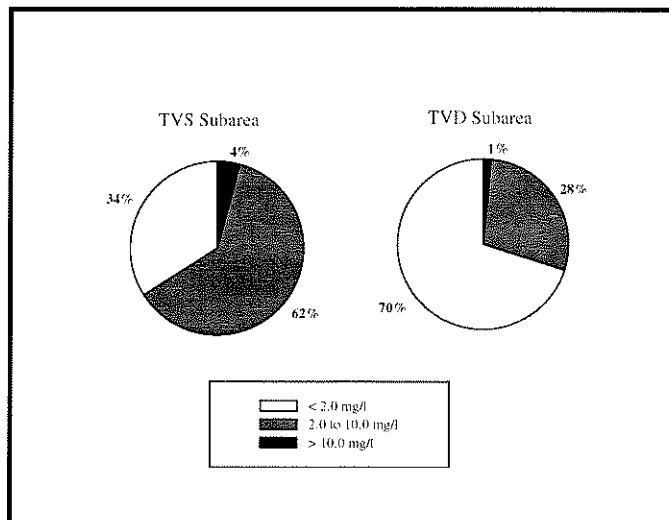


Figure 33. Pie charts showing ranges of nitrate concentrations and associated percentages for the TVS and TVD subareas, 1991-1994.

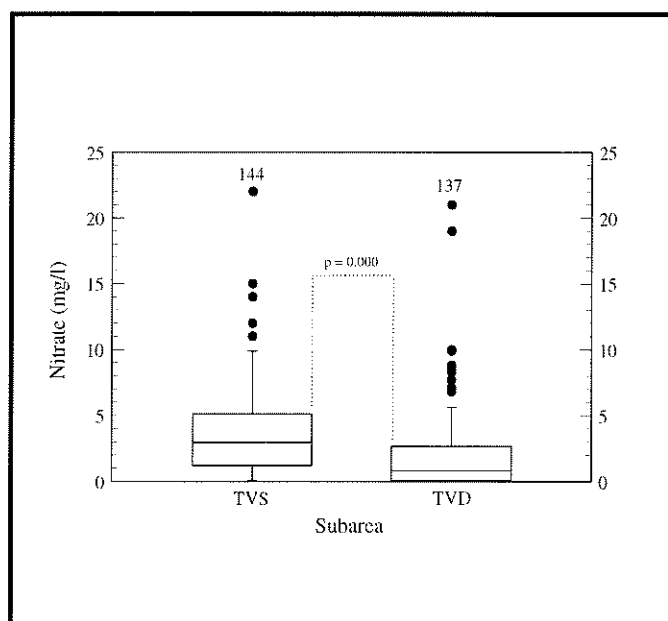


Figure 34. Boxplots and Mann-Whitney rank-sum test results for nitrate versus subarea designation for the Treasure Valley monitoring sites, 1991-1994.

(1997b) suggested these relationships indicate leaching of nitrate and salts from soils by excess irrigation. The cause and nature of the TDS/nitrate relationship in the Treasure Valley are unknown.

(Figure 38). Thirteen of the 16 TVS and TVD sites that had ammonia concentrations greater than 1.0 mg/l were associated with the agricultural land use category. Dissolved orthophosphorus concentrations for the TVD subarea ranged from less than the detection limit of 0.01 mg/l at 25 sites to 0.23 mg/l with the median being 0.02 mg/l. Eleven of the 137 TVD sites (eight percent) had orthophosphorus concentrations equal to or greater than 0.1 mg/l.

A scatterplot of dissolved nitrate versus well depth for all of the Treasure Valley Shallow and Deep monitoring sites showed a negative correlation between the two variables (Figure 41). The Spearman's rho test result indicates that there is a negative correlation between the two variables that is significant at the 95 percent confidence level; i.e., nitrate concentrations decreased as well depths increased.

A significant relationship at the 95 percent confidence level also existed for dissolved nitrate versus TDS where the Spearman's rho equaled 0.556 and p equaled 0.000 (Figure 42). In this case, TDS and nitrate concentrations had a positive correlation; as one variable increased, the other also increased. Rupert (1997b) reported a similar relationship between nitrate and bicarbonate, specific conductance, alkalinity, calcium, magnesium, chloride and sulfate in a study of ground water quality in the Upper Snake River Basin in Idaho and western Wyoming. Rupert

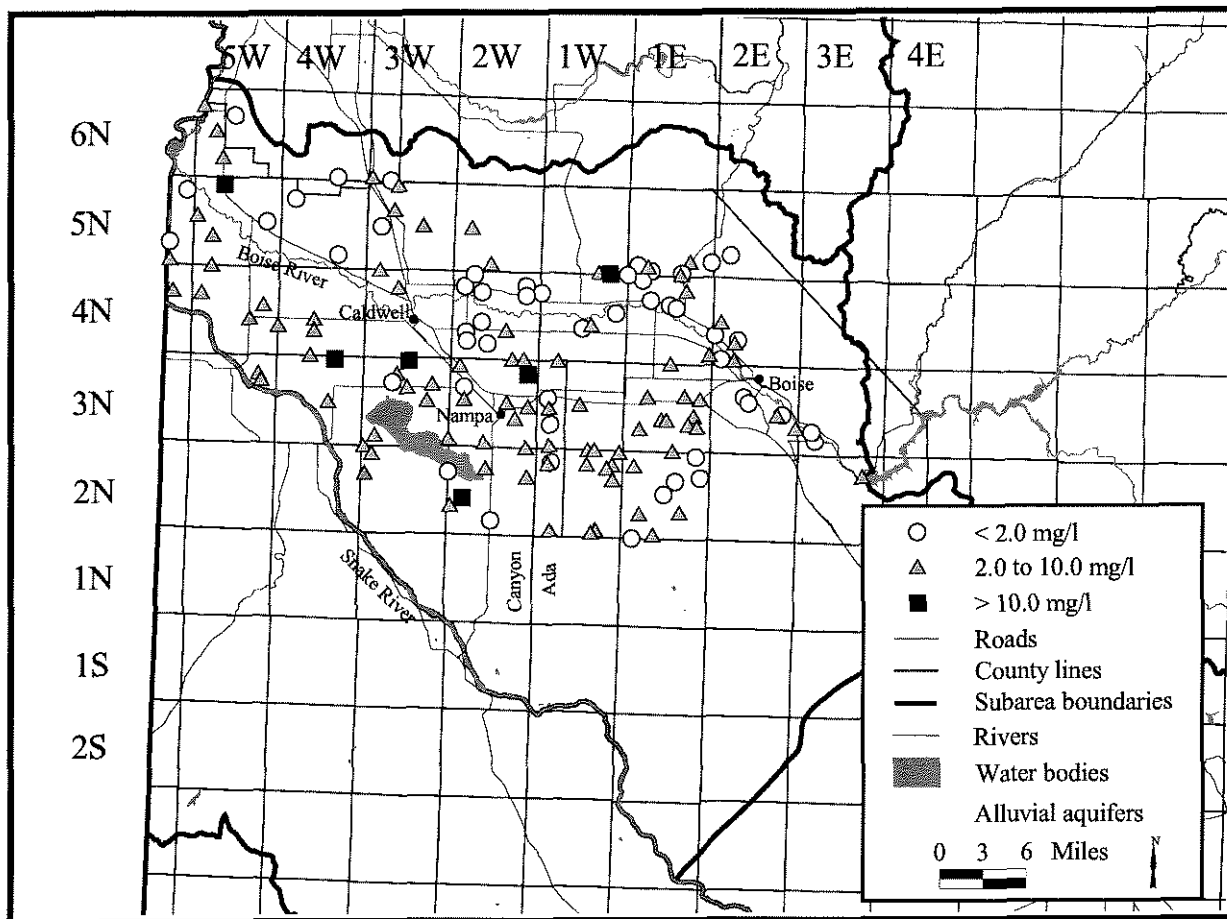


Figure 35. Dissolved nitrate concentrations for the Treasure Valley Shallow subarea, 1991-1994.

## Trace Elements

Arsenic, iron, manganese and zinc are the trace elements discussed for the TVS and TVD subareas. Cadmium, chromium, copper, lead and selenium are other trace elements that were analyzed and are included in Appendix A but are not discussed in this report because they contained high percentages of non-detections. Cyanide was also analyzed and is included in Appendix A.

The dissolved arsenic concentration at five sites was greater than the public drinking water MCL of 50 micrograms per liter ( $\mu\text{g/l}$ ). The highest arsenic concentrations for both the TVS and TVD subareas occurred in sites located south and west of Caldwell (Figure 43). Arsenic concentrations were generally higher in the southwestern parts of both subareas with some elevated concentrations in the northeastern areas (Figures 44 and 45). It is unknown whether the cause for the high arsenic concentrations is anthropogenic (historic pesticide use),

geologic or a combination of sources. The median arsenic values for the TVS and TVD subareas were not significantly different at the 95 percent confidence level.

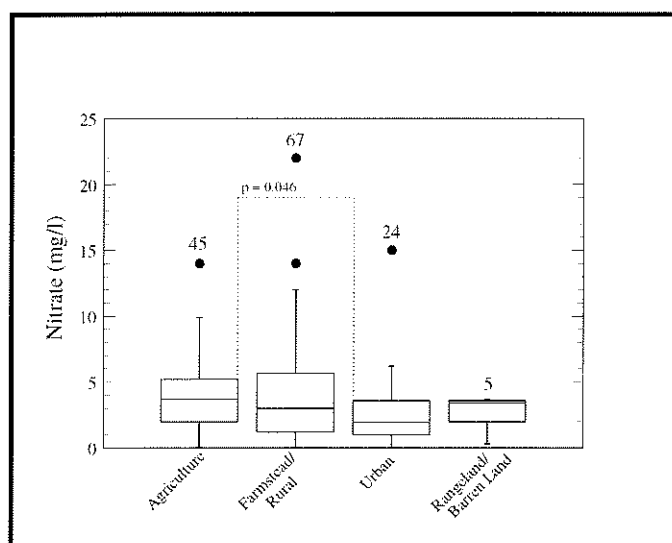


Figure 36. Boxplots and Mann-Whitney rank-sum test results for nitrate concentrations at TVS sites versus land use category, 1991-1994.

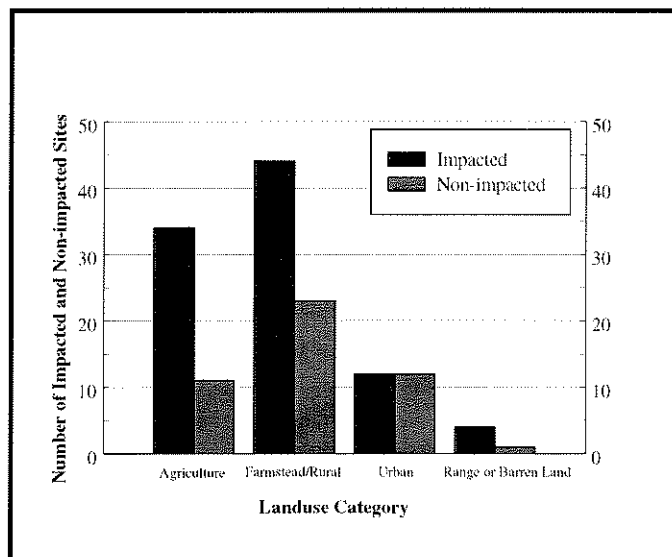


Figure 37. Number of TVS sites with impacted nitrate levels ( $\geq 2.0$  mg/l) and non-impacted nitrate levels ( $< 2.0$  mg/l) by land use category, 1991-1994.

concentration for the TVD subarea at the 95 percent confidence level.

The majority of sites in both subareas had dissolved iron concentrations between 3 and 150  $\mu\text{g/l}$ . Higher concentrations were found in sites in the northeastern and southwestern areas and along the Idaho-Oregon border where 11 sites had concentrations that exceeded the secondary MCL of 300  $\mu\text{g/l}$ . Seven of the 11 detections above the secondary MCL were from TVD subarea sites. The median iron concentration for the TVD subarea was significantly higher than the median concentration for the TVS subarea at the 95 percent confidence level.

Dissolved manganese concentrations greater than the secondary MCL of 50  $\mu\text{g/l}$  occurred in sites along the western and northeast margins of the subareas. The median manganese concentration for the TVD subarea was significantly higher than the median for the TVS subarea at the 95 percent confidence level.

A majority of sites had dissolved zinc concentrations greater than the laboratory detection limit of 3.0  $\mu\text{g/l}$ . The maximum zinc concentrations for the TVS and TVD subareas were 460 and 670  $\mu\text{g/l}$ , respectively (the secondary MCL is 5,000  $\mu\text{g/l}$ ). The higher zinc concentrations occurred in the central part of the TVS subarea and along the edges of the TVD subarea. The median concentration for the TVS subarea was significantly higher than the median



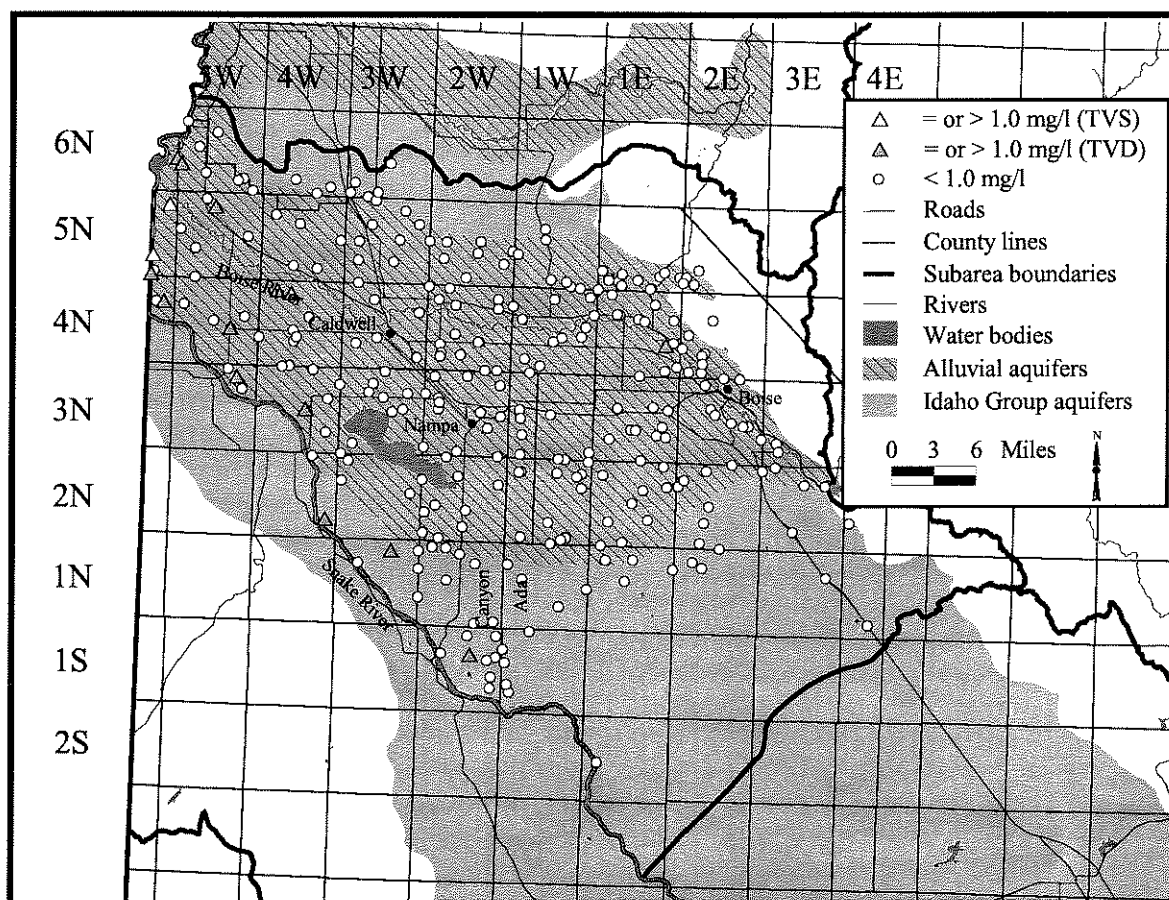


Figure 38. Dissolved ammonia concentrations for the Treasure Valley Shallow and Deep subareas, 1991-1994.

## Radioactivity

Radioactivity analyses included total gross alpha, total gross beta, radon, total uranium, radium-226 and uranium isotopes. Total gross alpha and total gross beta samples were collected at all of the sites. Radon samples were collected at only 66 percent of the sites due to the maximum 24 hour holding time for laboratory analysis. Total uranium and radium-226 were analyzed at 43 sites where total gross alpha values approached or exceeded the MCL of 15.0 picocuries per liter (pCi/l). Six of the 43 speciated samples were analyzed for uranium isotopes (233 and 234, 235 and 238).

For public drinking water regulatory purposes, the MCL is an *adjusted gross alpha* concentration where uranium is removed from the total gross alpha radioactivity concentration. Although the regulations do not specify which uranium isotope is to be removed, we assumed it to be total uranium (uranium-238). An actual adjusted gross alpha concentration was calculated for the 43 sites where the ground water was speciated for total uranium and radium-226. An

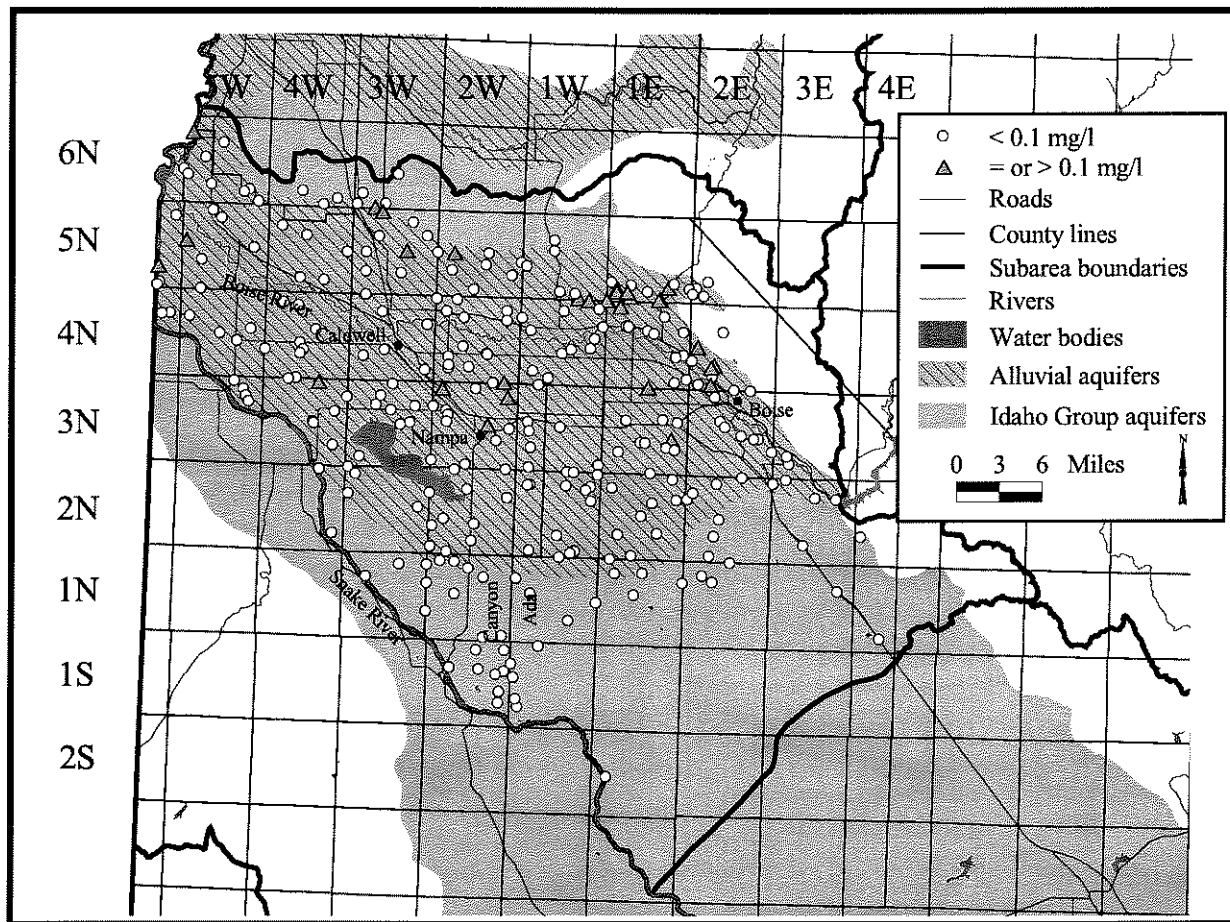


Figure 39. Dissolved orthophosphorus concentrations for the Treasure Valley Shallow and Deep subareas, 1991-1994.

estimated adjustment factor of 0.63 was calculated by computing the average of the ratios of adjusted gross alpha to total gross alpha for the 43 sites. An estimated adjusted gross alpha concentration was calculated for all of the other sites (where speciation was not performed) by multiplying the total gross alpha concentration by 0.63.

Total gross alpha and total gross beta median radioactivity concentrations were significantly higher for the TVS subarea than for the TVD subarea (Figures 46 and 47). Adjusted gross alpha values were generally higher in the central part of the TVS subarea (Figure 48) and along the margins of the TVD subarea (Figure 49). Adjusted gross alpha concentrations exceeded the primary MCL of 15.0 pCi/l at 17 sites (12 percent) in the TVS subarea and at 6 sites (four percent) in the TVD subarea.

Total gross beta concentrations were also higher in the central part of the TVS subarea and in the southern and western parts of the TVD subarea (generally along the Snake River). One site in the TVS subarea had a total gross beta concentration that exceeded 50 pCi/l (The

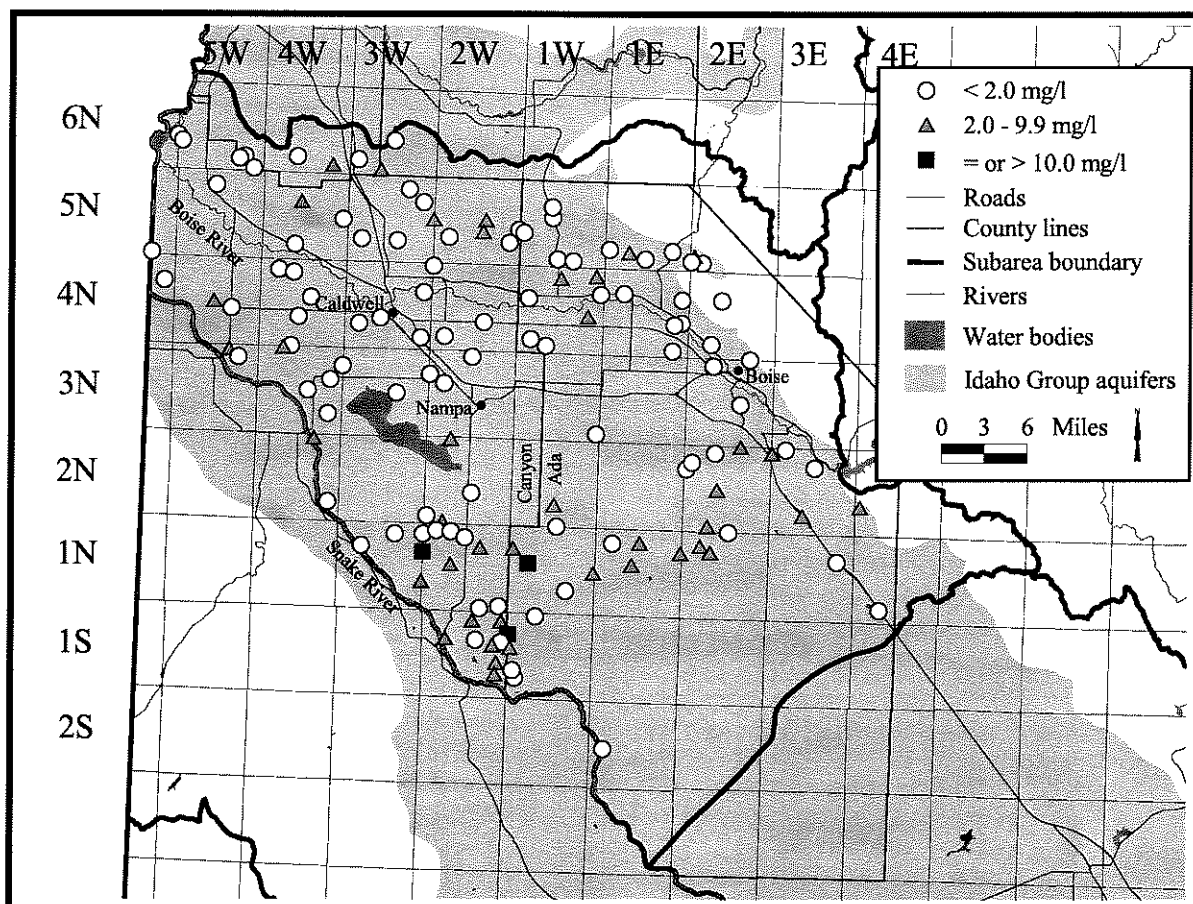


Figure 40. Dissolved nitrate concentrations for the Treasure Valley Deep subarea, 1991-1994.

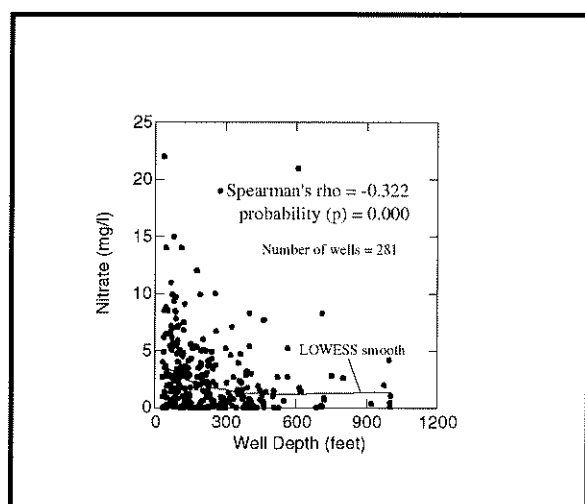


Figure 41. Scatterplot and Spearman's rho test results for nitrate versus well depth for TVS and TVD monitoring sites, 1991-1994.

primary MCL for gross beta is a dose of four millirems per year which could be achieved by an average annual concentration of 50 pCi/l).

Uranium was the primary alpha emitter in 41 of the 43 speciated samples. Total uranium (uranium-238) results ranged from 9  $\mu\text{g/l}$  to 110  $\mu\text{g/l}$ . Twenty-four of the 33 TVS subarea samples and nine of the 10 TVD subarea samples had total mass uranium concentrations that exceeded the proposed MCL of 20  $\mu\text{g/l}$  (Figure 50). The median uranium values for the TVS and TVD subareas were not significantly different at the 95 percent confidence level. Radium-226 radioactivity concentrations exceeded the primary MCL of 5

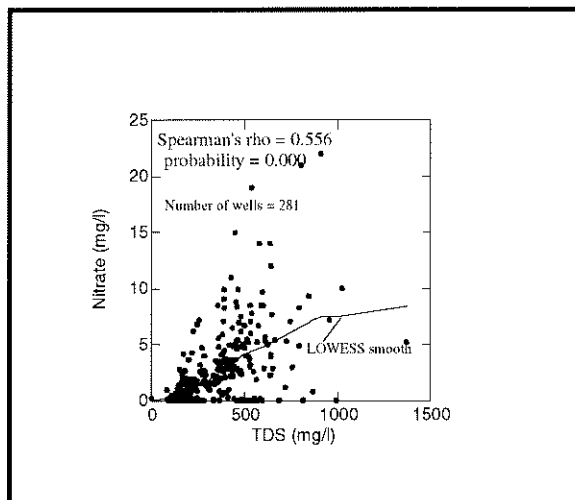


Figure 42. Scatterplot and Spearman's rho test results for nitrate versus TDS for TVS and TVD monitoring sites, 1991-1994.

pCi/l at 2 of the 43 sites. The two TVS sites were not related to each other (one located southeast of Boise; the other located southwest of Nampa) and the radium-226 values at these sites were more than an order of magnitude higher than all surrounding data.

Uranium isotopes ( $^{233}$  and  $^{234}$ ,  $^{235}$  and  $^{238}$ ) were determined at six of the 43 speciated water samples. Uranium-238 is the only isotope with enough atomic weight to be used for calculating total uranium by volume. The radioactivity concentration of uranium-233 and uranium-234 for the six isotope analyses was, on the average, two times greater than the uranium 238 concentrations.

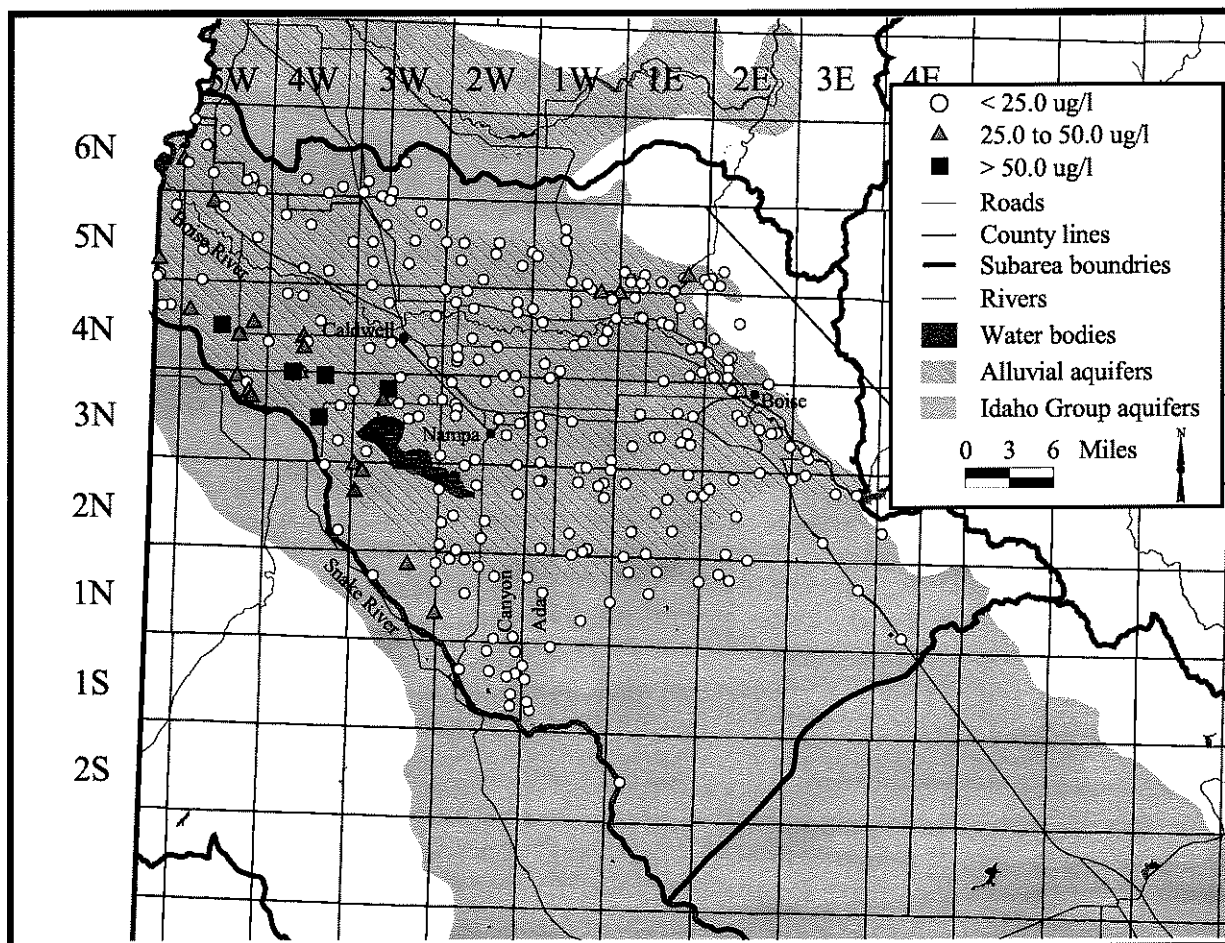


Figure 43. Dissolved arsenic concentrations for the Treasure Valley Shallow and Deep subareas, 1991-1994.

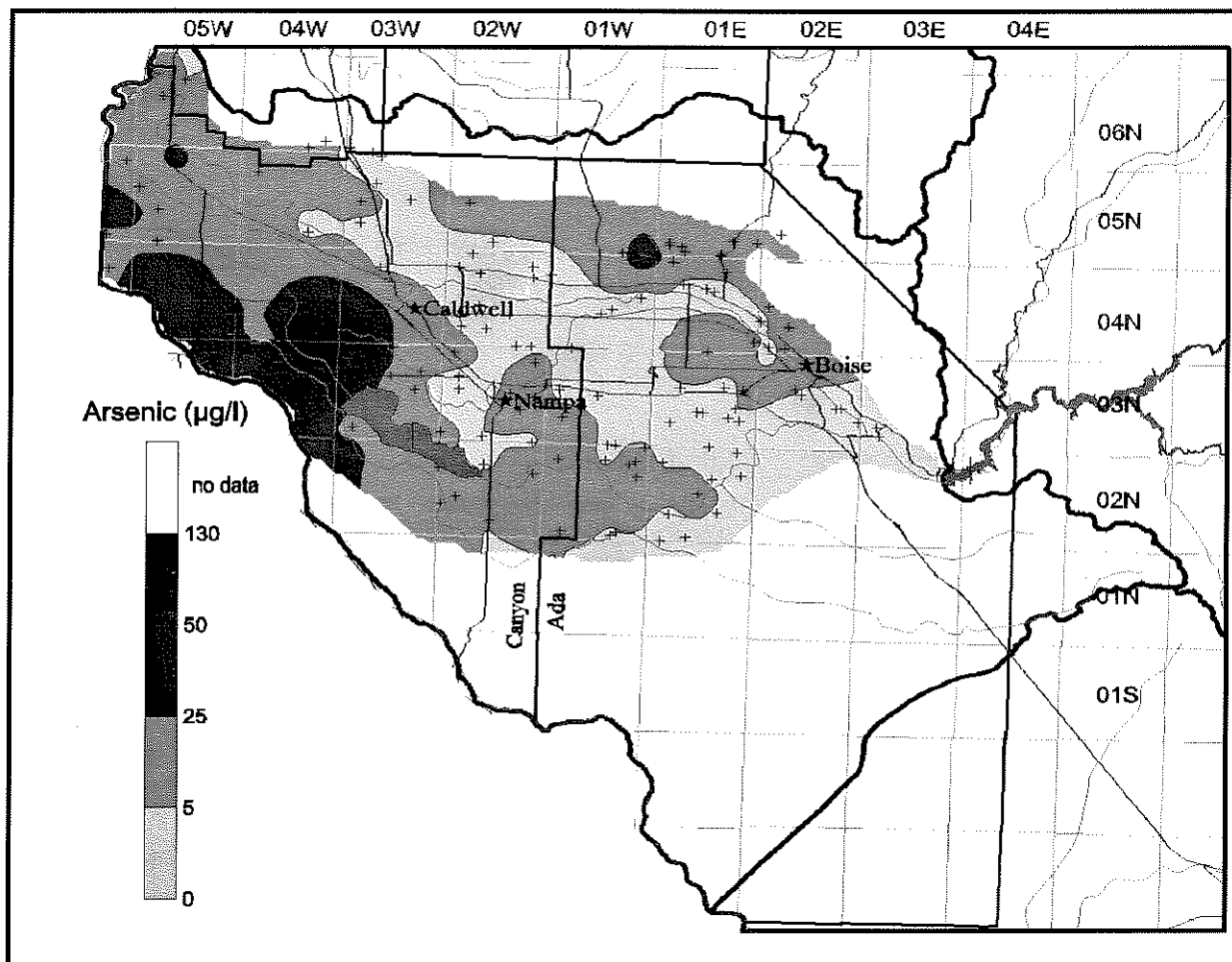


Figure 44. Contour map for dissolved arsenic concentrations for the Treasure Valley Shallow subarea, 1991-1994.

The median radon concentration for the TVS subarea was significantly higher than the median value for the TVD subarea at the 95 percent confidence level. Radon concentrations for the TVS subarea decreased from east to west (Figure 51), which is the same general direction of the ground water flowpaths (Figure 11). Radon concentrations in the TVS subarea may be decreasing with increasing distance from the Idaho Batholith granitic rocks (which are the probable sources for the radon). Radon concentrations for the TVD subarea were highest in the southeastern part of the subarea. No discernible pattern of radon concentrations existed for the rest of the TVD subarea.

## **Volatile Organic Compounds**

Volatile organic compounds (VOCs) are synthetic chemicals that can be toxic to

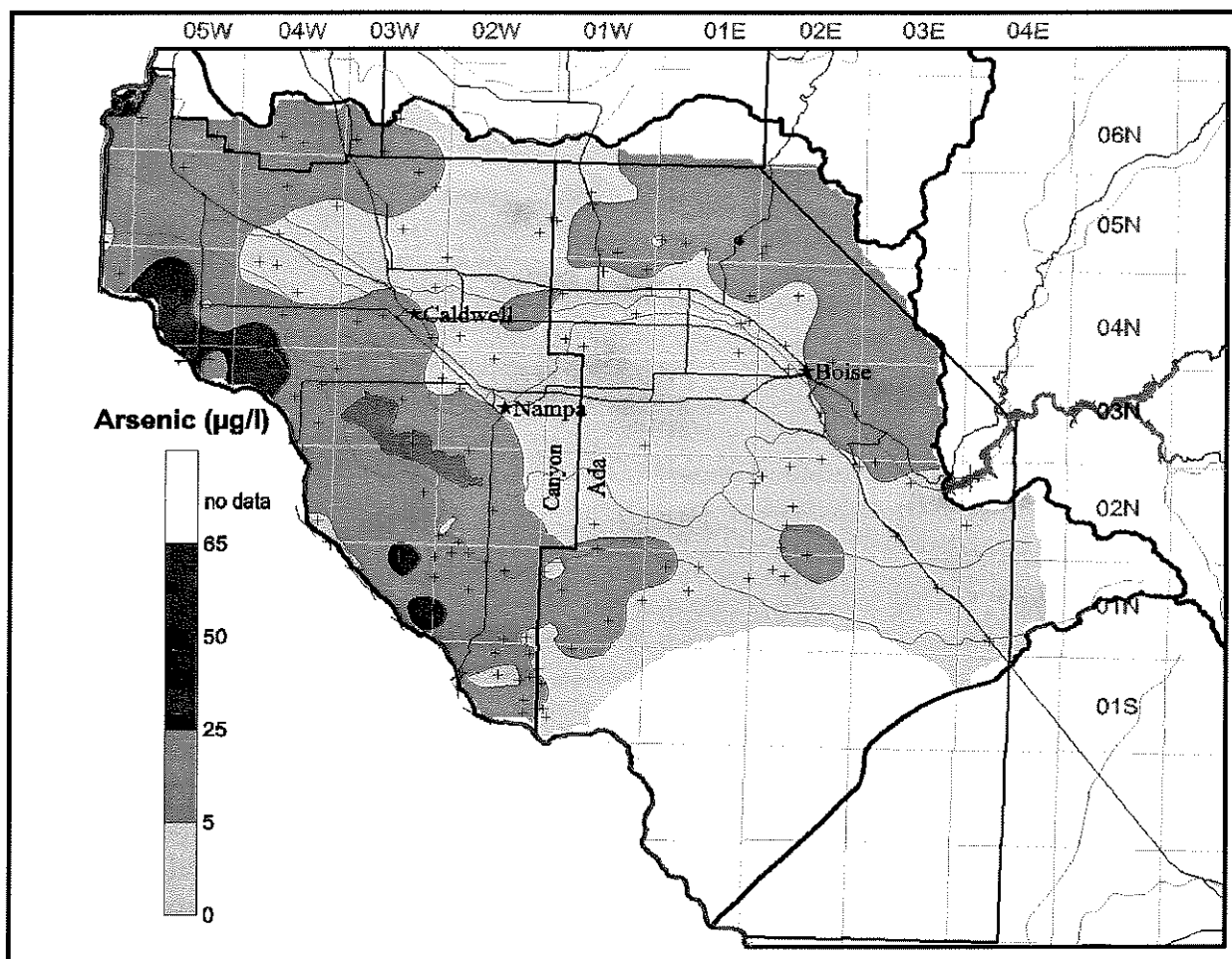


Figure 45. Contour map for dissolved arsenic concentrations for the Treasure Valley Deep subarea, 1991-1994.

humans, animals and plants. The presence of VOCs in ground water indicates that human activities have impacted the water quality. Ground water samples were analyzed for a wide spectrum of VOCs using EPA methods 502.2 and 524.2.

Ground water at 11 of the 281 TVS and TVD subarea sites (four percent) had one or more of the following VOC compounds: dichloropropane (DCP), trichloropropane (TCP), perchloroethylene (Perc or PCE), trichloroethane (TCA), toluene and xylene (Figure 52). An additional four sites tested positive for trihalomethanes (which are often byproducts of chlorination). Ten of the 11 sites with VOC detections occurred in the TVS subarea. The single TVD subarea well with a VOC detection was only 138 feet deep but had blue shale above the perforated interval. Two sites had VOC concentrations that exceeded primary MCLs (DCP and Perc (PCE) at one site each).

Five of the 11 Statewide Program sites with VOC detections tested positive for DCP and



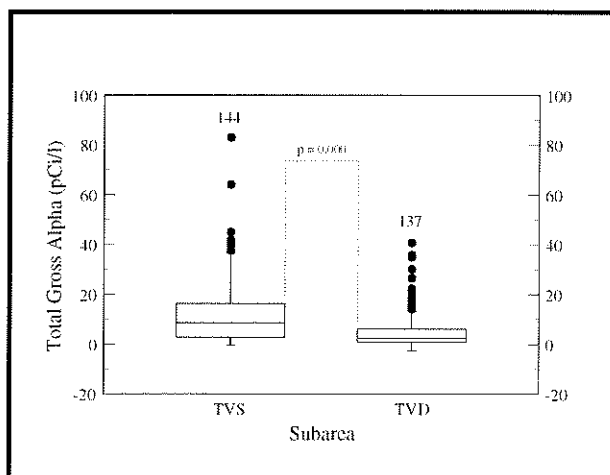


Figure 46. Boxplots and Mann-Whitney rank-sum test results for total gross alpha versus subarea designation, 1991-1994.

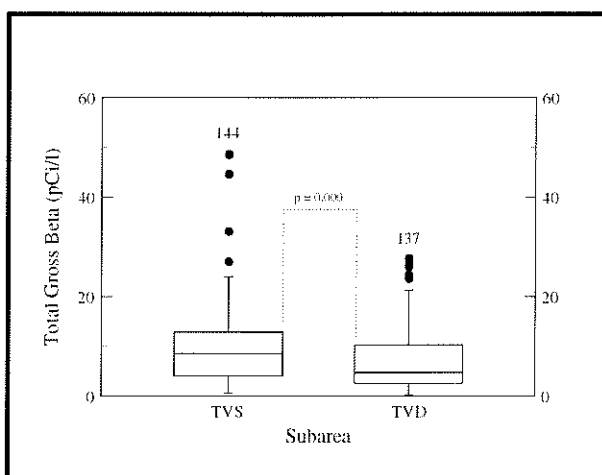


Figure 47. Boxplots and Mann-Whitney rank-sum test results for total gross beta versus subarea designation, 1991-1994.

TCP, compounds that were once used as soil fumigants in agricultural land but the uses of which have been discontinued. Four sites tested positive for Perc (PCE) which was a compound used commonly in the past in industrial solvents and in the dry cleaning industry.

The ISDA conducted a follow-up study in an area north of Eagle (Township 5 North, Range 1 West) where three closely-spaced Statewide Program sites had detections of DCP and TCP. Eighteen wells were tested for VOCs by the ISDA in 1991 and 1992. The ISDA found DCP and TCP in the ground water of five wells and DCP only in a sixth well (Whitney and others, 1992). The DEQ found DCP in the ground water of a well located at the property adjacent to the original detection. In all, five of the 10 wells with VOC detections in this area had dichloropropane greater than the primary MCL of 5.0  $\mu\text{g/l}$ . An additional study in the general area by the ISDA in 1995 found VOCs in 16 of the 39 wells tested (Boyle, 1997).

## Pesticides

Pesticides in this report includes fungicides, herbicides, nemotocides, insecticides and rhodenticides. Three methods were used to test for pesticides in ground water samples: VOC analyses, immunoassays and gas chromatograph (GC). Pesticides detected through VOC analyses were discussed in the Volatile Organic Compounds section. Immunoassay tests were performed on 97 percent of the sites in the two Treasure Valley subareas. GC pesticide analyses were run on 68 percent of the TVS sites and 11 percent of the TVD sites.

Immunoassays (enzyme-linked immunosorbent assays or ELISA) are enzyme-specific tests developed originally for the medical field that are now also being used for environmental monitoring (Vanderlaan and others, 1988). Immunoassay tests were selected for use in the Statewide Program because they are inexpensive, relatively easy to perform, unlikely to produce

false negatives and have detection limits as low as, or lower than, some GC analyses. Each test is designed for a specific pesticide family (for example, the atrazine test will check for several compounds within the triazine family). Immunoassay tests are currently available for a limited number of pesticide families. The tests do not provide analyte-specific results for the compounds within each family because of cross-reactivity.

Immunoassay tests have been used in the Statewide Program since its inception in 1990. Data from 1992 through 1995 were summarized and interpreted for this report. Data from 1991 were not used because of laboratory quality control problems. The number of tests (for pesticide families) performed on each ground water sample increased from three to seven between 1992 and 1995 as a result of new tests produced by the manufacturer and additional funding provided by the ISDA.

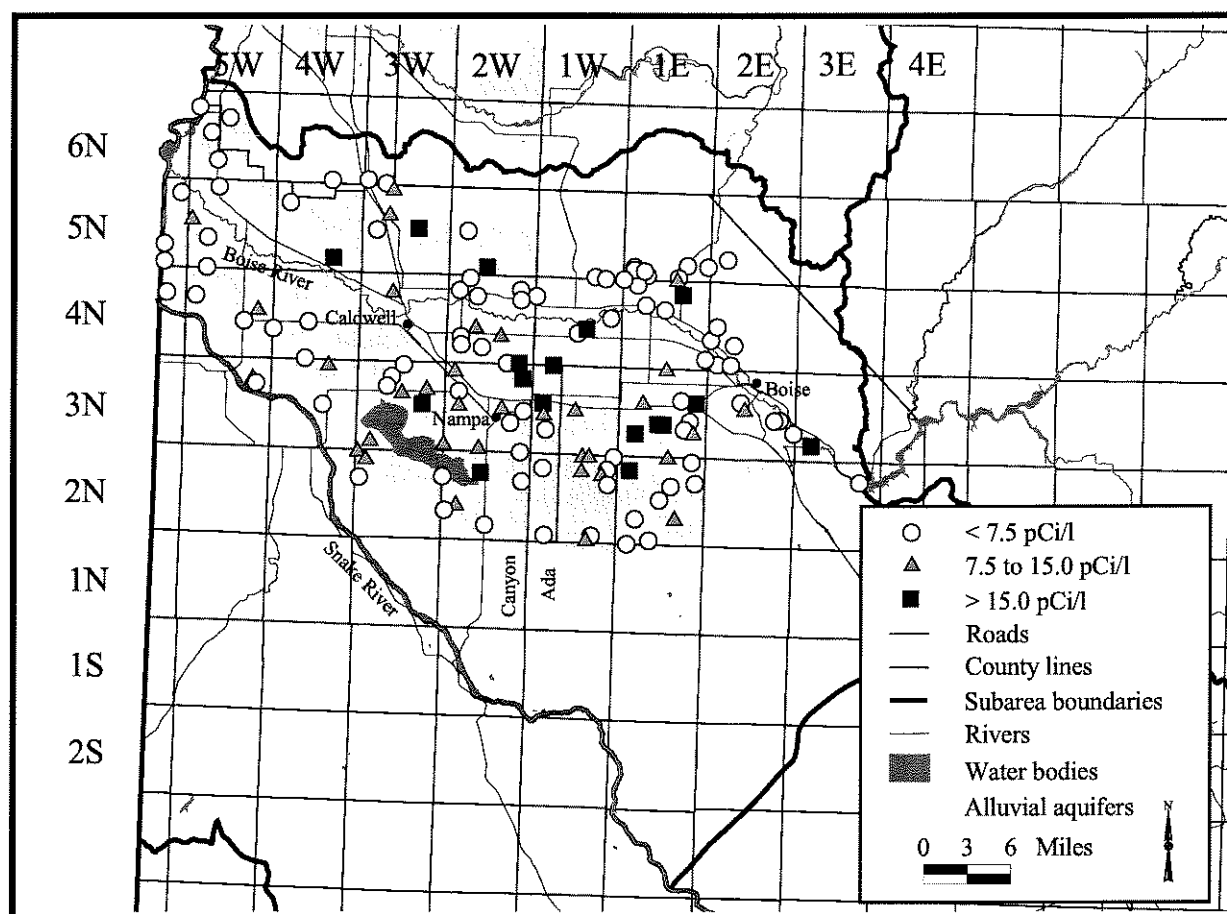


Figure 48. Adjusted gross alpha radioactivity concentrations for the Treasure Valley Shallow subarea, 1991-1994.



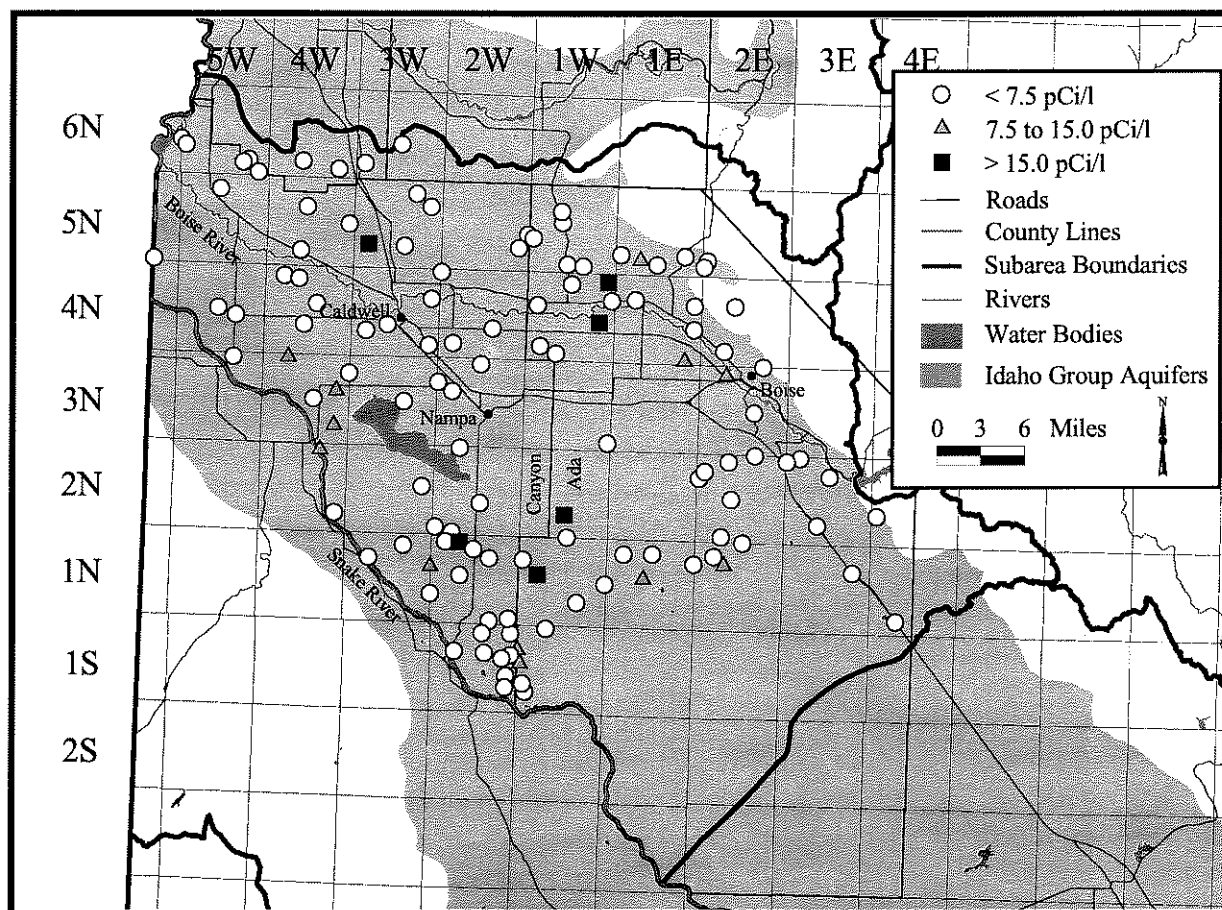


Figure 49. Adjusted gross alpha radioactivity concentrations for the Treasure Valley Deep subarea, 1991-1994.

Results for the TVS subarea indicated that 23 percent of the sites with immunoassay testing had at least one confirmed detection of a pesticide compound (a confirmed detection had a positive result on the initial test followed by another positive result for the same compound from a second test conducted on the same sample water). Atrazine had the highest number of confirmed detections (Table 3). An additional six percent of the samples tested had unconfirmed detections (positive on the initial test and negative on the second test). Unconfirmed detections were probably caused by either compound degradation (between the times of the two tests) or a false positive on the initial test. None of the detections exceeded any existing or proposed MCLs, or any Health Advisory levels. Most detections were about an order of magnitude below the MCLs. The frequency of detections was highest in the southcentral part of the TVS subarea (Figure 53).

The percentage of immunoassay detections for the TVD subarea was about one-sixth of the percentage for the TVS subarea (Table 3). Atrazine and alachlor were the most commonly detected pesticide families for the TVD subarea. Most of the TVD detections occurred in an area south of Nampa (Figure 54). Concentrations were well below MCLs and Health Advisory levels.

Table 3. Immunoassay results for the TVS and TVD subareas, 1992-1995.

Subarea	# of sites with immunoassay analyses	# of sites with detections (% of sites with detections)	Detections per compound family <sup>1</sup>
TVS	139	32 (23%)	Atrazine (26), Alachlor (6), Aldicarb (1), Carbofuran (1), Cyanazine (1)
TVD	133	5 (4%)	Alachlor (2), Atrazine (2), Aldicarb (1)

<sup>1</sup> The sum of individual detections is greater than the number reported in the "# of sites with detections" column because some sites had more than one compound detected.

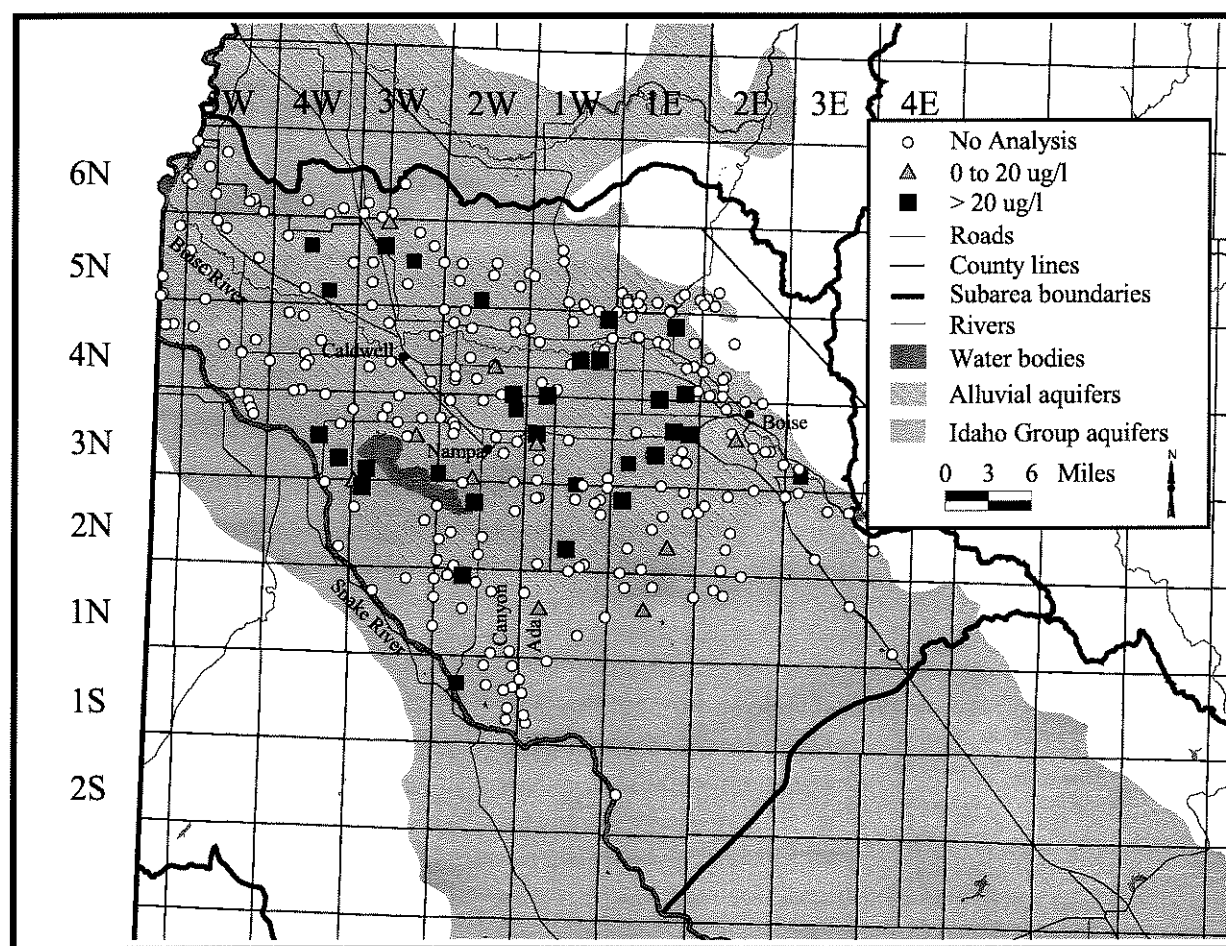


Figure 50. Total uranium concentrations for the Treasure Valley Shallow and Deep subareas, 1991-1994.

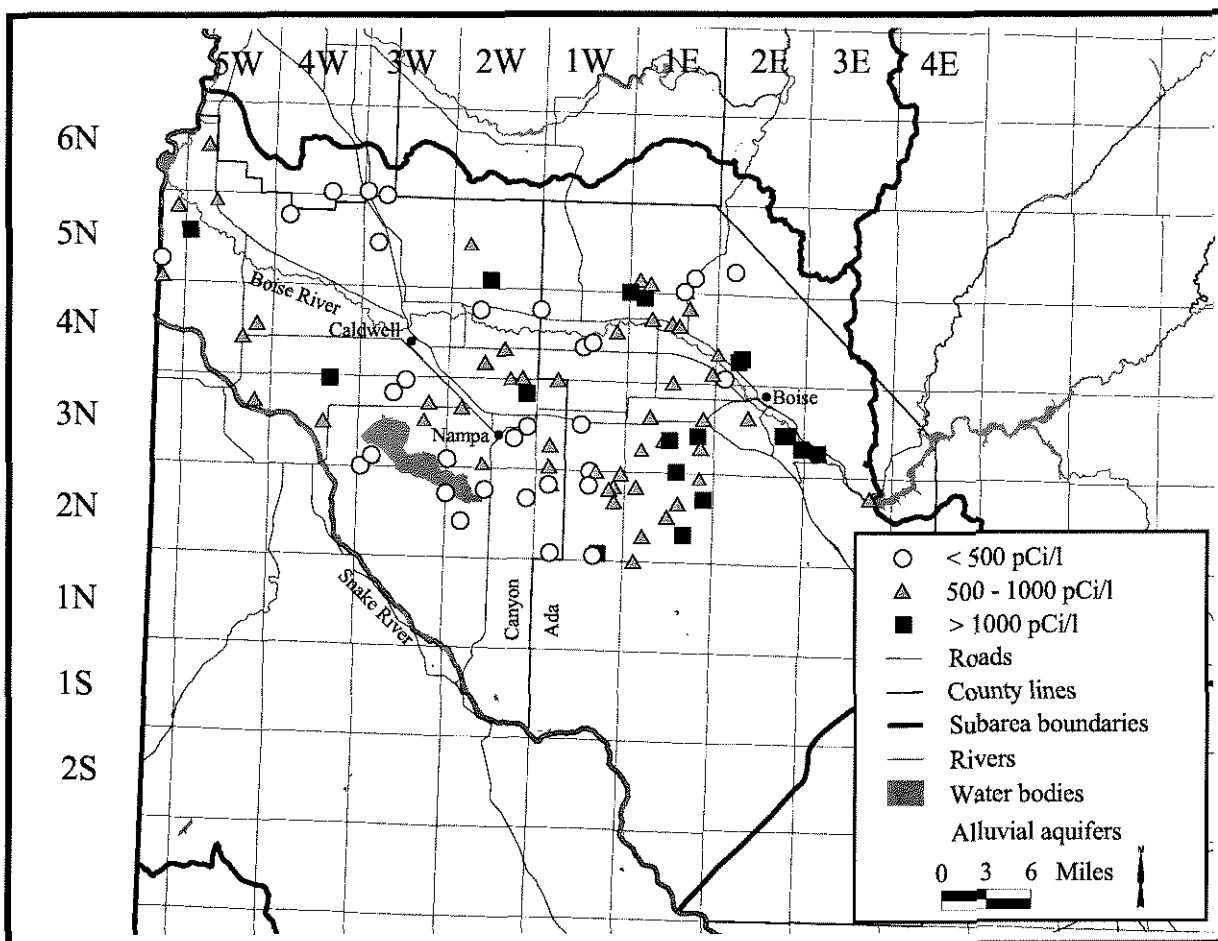


Figure 51. Radon radioactivity concentrations for the Treasure Valley Shallow subarea, 1991-1994.

Gas chromatography (GC) analyses were conducted on shallow wells (less than 300 feet deep) in the Treasure Valley in 1993, 1995, 1996 and 1997 (the number of samples was limited by the high laboratory costs of GC tests). In 1993, 50 samples were analyzed for 25 compounds using EPA Methods 507, 508, 515.1, 531.1 and 8141 (the laboratory detection limits for these methods is in the parts per billion range). Dacthal was detected at three sites (six percent) and metribuzin was detected at one site (two percent).

Samples from 98 TVS subarea sites collected in 1995, 1996 and 1997 were analyzed for 46 compounds using USGS method 2001 which is a solid-phase extraction method that produces repeatable results in the parts per trillion range. One or more pesticides were detected at 82 of the 98 sites (84 percent). Atrazine or deethylatrazine (a degradation product of atrazine) was present at all 82 sites with detections; simazine was detected at 38 sites. Additional pesticides detected were alachlor, carbaryl, chlorpyrifos, DCPA, 2,6-diethylaniline, EPTC,

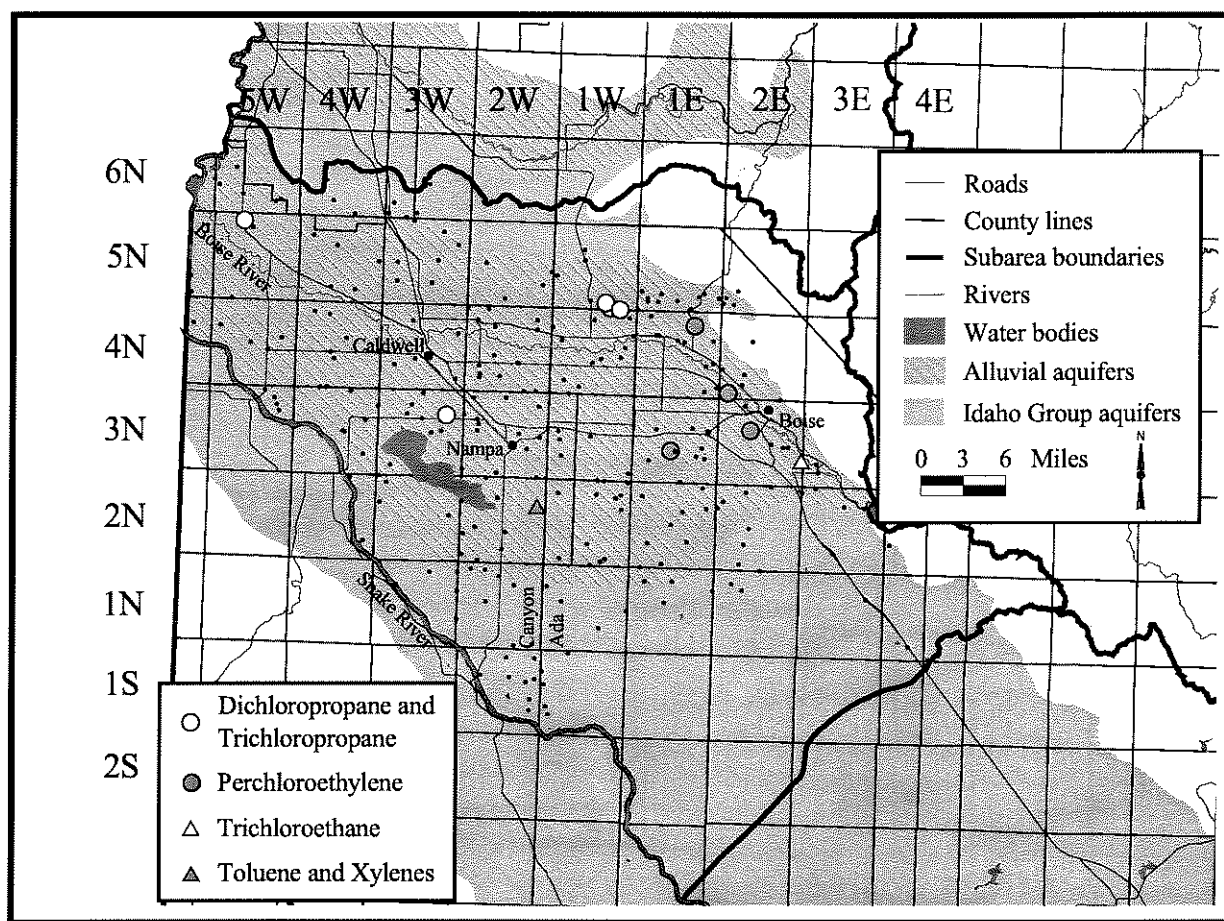


Figure 52. Detections of volatile organic compounds (VOCs) for the Treasure Valley Shallow and Deep subareas, 1991-1994.

metolachlor, metribuzin, napropamide, prometon, P,P'DDE, tebuthiuron, terbacil and trifluralin. Three sites were tested in 1995, 1996 and 1997. The pesticides detected at these three sites in 1995 were detected again in 1996 and 1997, along with additional pesticides not detected in 1995 (see detailed discussion for these sites in the Trend Monitoring section).

All GC pesticide results were below the MCLs with most of the concentrations being at least one order of magnitude below the MCLs. Geographic patterns of pesticide detections cannot be accurately discerned until all of the sites in both the TVS and TVD subarea have been tested for pesticides using the USGS 2001 method (Figure 55).

## Bacteria

Ground water samples were tested for fecal coliform bacteria primarily as a courtesy to the site owner. Samples were filtered, incubated and analyzed in the field. Fecal coliform bacteria originate from the waste products of humans and warm blooded animals. The presence

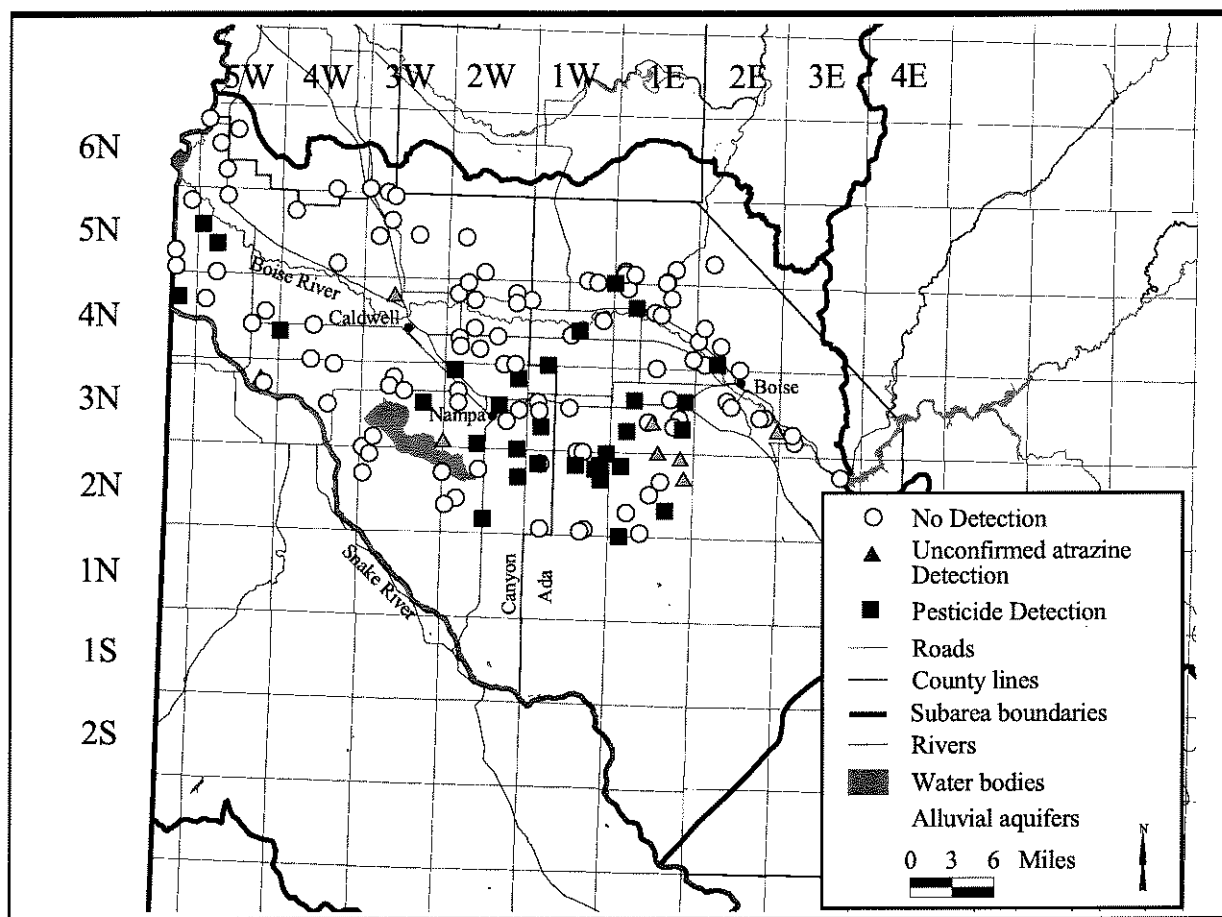


Figure 53. Immunoassay pesticide test results for the Treasure Valley Shallow subarea, 1992-1995.

of one or more fecal coliform bacteria colonies in the ground water indicates that the ground water quality has been impacted by surface or near-surface activities.

Twelve of the 270 sites (four percent) tested for fecal coliform bacteria in the TVS and TVD subareas had positive detections of one or more bacteria colonies. Seven sites in the TVS subarea had fecal coliform detections (Figure 56). The range of depths for the wells in the TVS subarea with fecal coliform detections was 32 to 190 feet with an average well depth of 100 feet. Five sites in the TVD subarea had fecal coliform detections (Figure 56). Depths for the wells in the TVD subarea with fecal coliform detections ranged from 145 to 410 feet with an average well depth of 266 feet.

## Characterization Summary

The Treasure Valley cold water aquifer system is comprised of two hydrogeologic

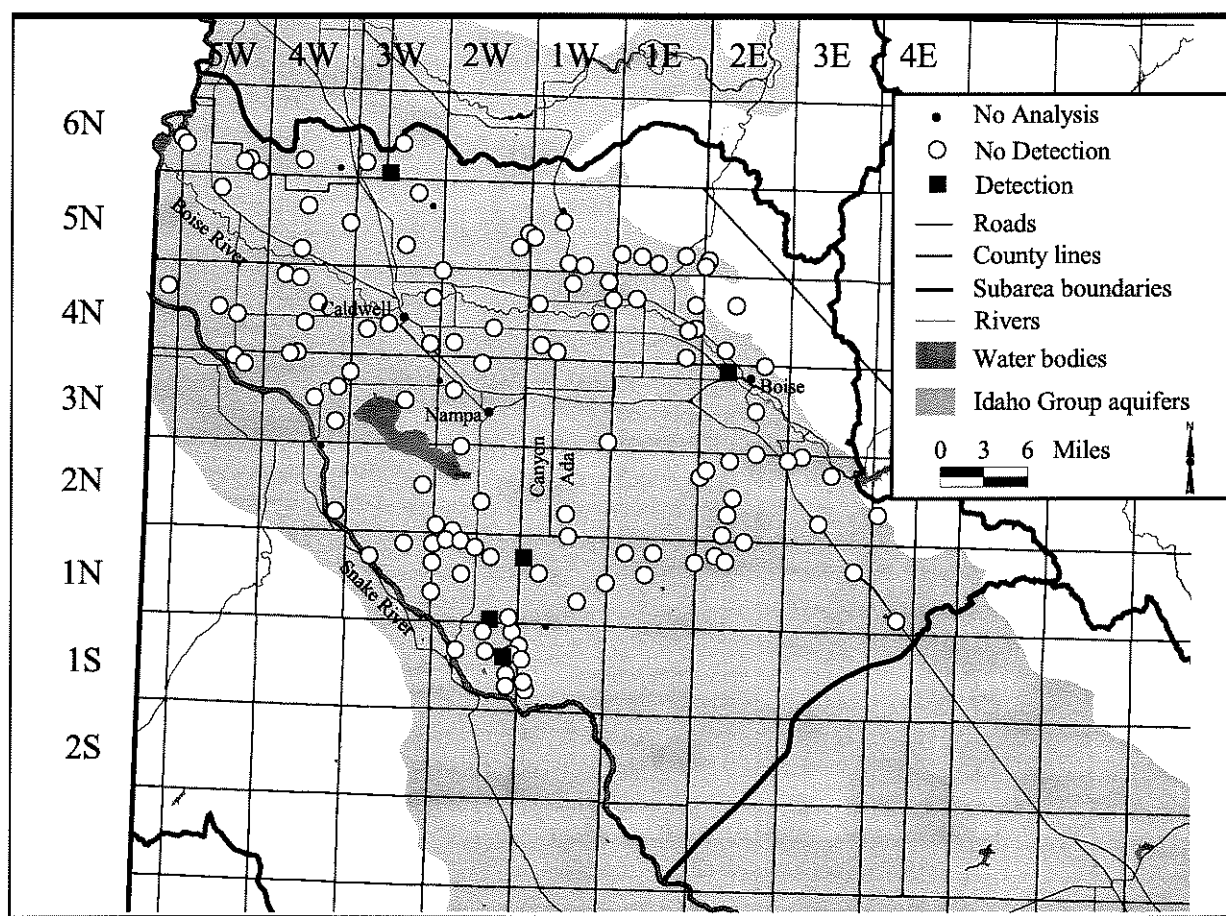


Figure 54. Immunoassay pesticide test results for the Treasure Valley Deep subarea, 1992-1995.

sources which have been treated as separate subareas. The deeper and more regional system, which contains fine grained sands, clays and occasional gravels, is the Treasure Valley Deep subarea. The TVD subarea is generally equivalent to the Idaho Group. The shallower and more localized ground water system is the Treasure Valley Shallow subarea. The TVS subarea, which is generally equivalent to the Snake River Group, contains coarse grained sands, gravels and minor basalt flows. Characterization of the ground water quality for both subareas was accomplished using data collected through the Statewide Program for 1991 through 1994 and pesticide data collected in 1995, 1996 and 1997. Appendix A contains the percentages for all major constituents.

Ground waters from the TVS subarea tended to have lower water temperatures, slightly lower pH, almost twice the total dissolved solids and higher natural radiation (alpha, beta and radon) than ground waters from the TVD subarea. The TVS subarea is more susceptible to contamination from land use activities than the TVD subarea because the aquifers are closer to the land surface and are usually not overlain by significant confining clay layers to protect them

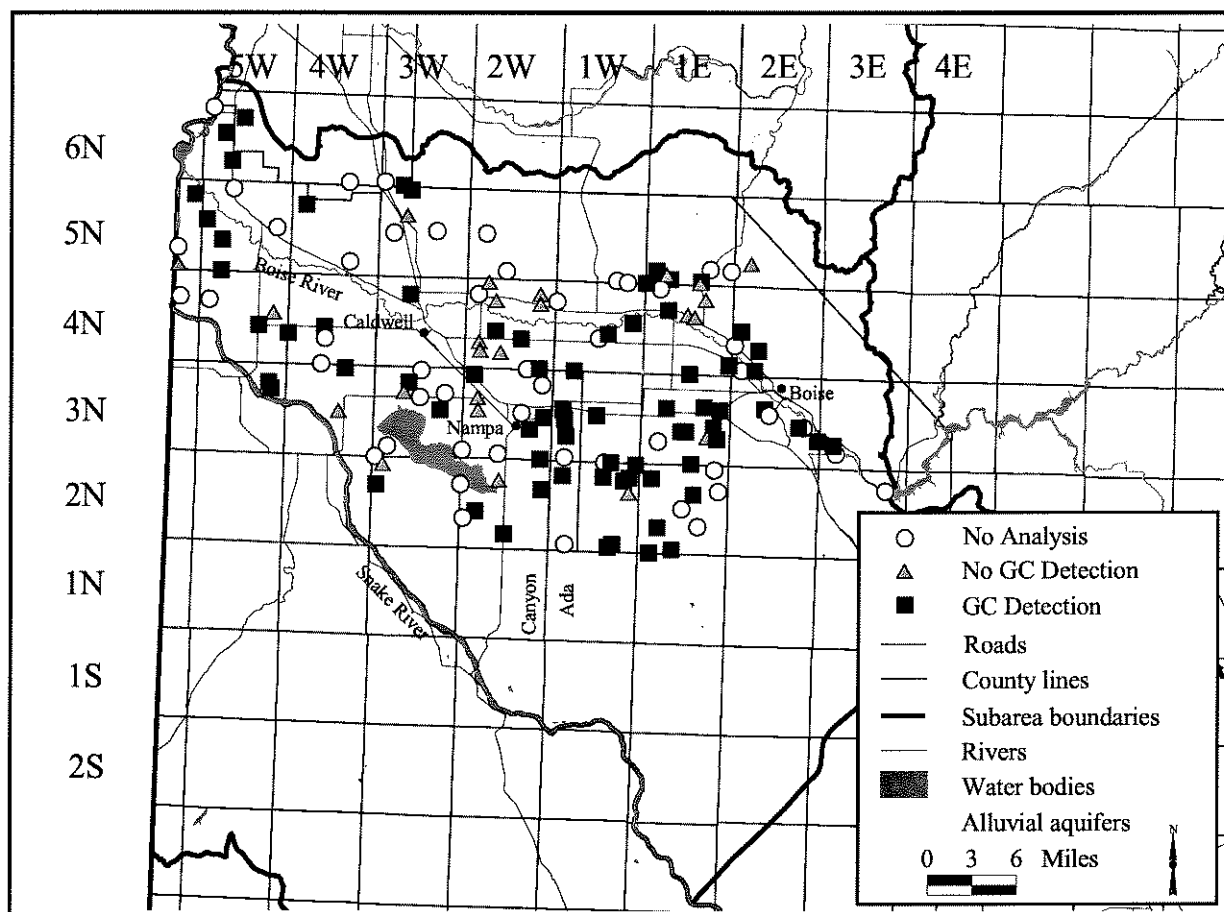


Figure 55. Gas chromatography pesticide test results for the Treasure Valley Shallow subarea, 1993, 1995, 1996 and 1997.

from downward migration of contaminants. The median nitrate concentration for the TVS subarea was about three and one-half times the median nitrate concentration for the TVD subarea. The occurrence of pesticides (detected by immunoassay) and VOCs was much higher in the TVS subarea (23 and 7 percent, respectively) than in the TVD subarea (4 and 0.7 percent, respectively).

The TVD subarea had a slightly higher potential for iron and manganese content in the ground water (even though the two highest concentrations were TVS sites). The TVD subarea had higher ammonia concentrations than the TVS subarea for unknown reasons. Most of the ammonia detections occurred near the Snake River in the western part of the Treasure Valley.

Both subareas had fairly equal potentials for elevated arsenic concentrations. The median arsenic values were not statistically different at the 95 percent confidence level and both subareas had detections that exceeded the MCL. Both subareas showed an equal potential for fluoride concentrations with at least 90 percent of all sites having concentrations below 0.9 mg/l.



However, fluoride concentrations may be very high in some ground waters of the Treasure Valley where the geothermal aquifer is being used because cold water aquifers are not present.

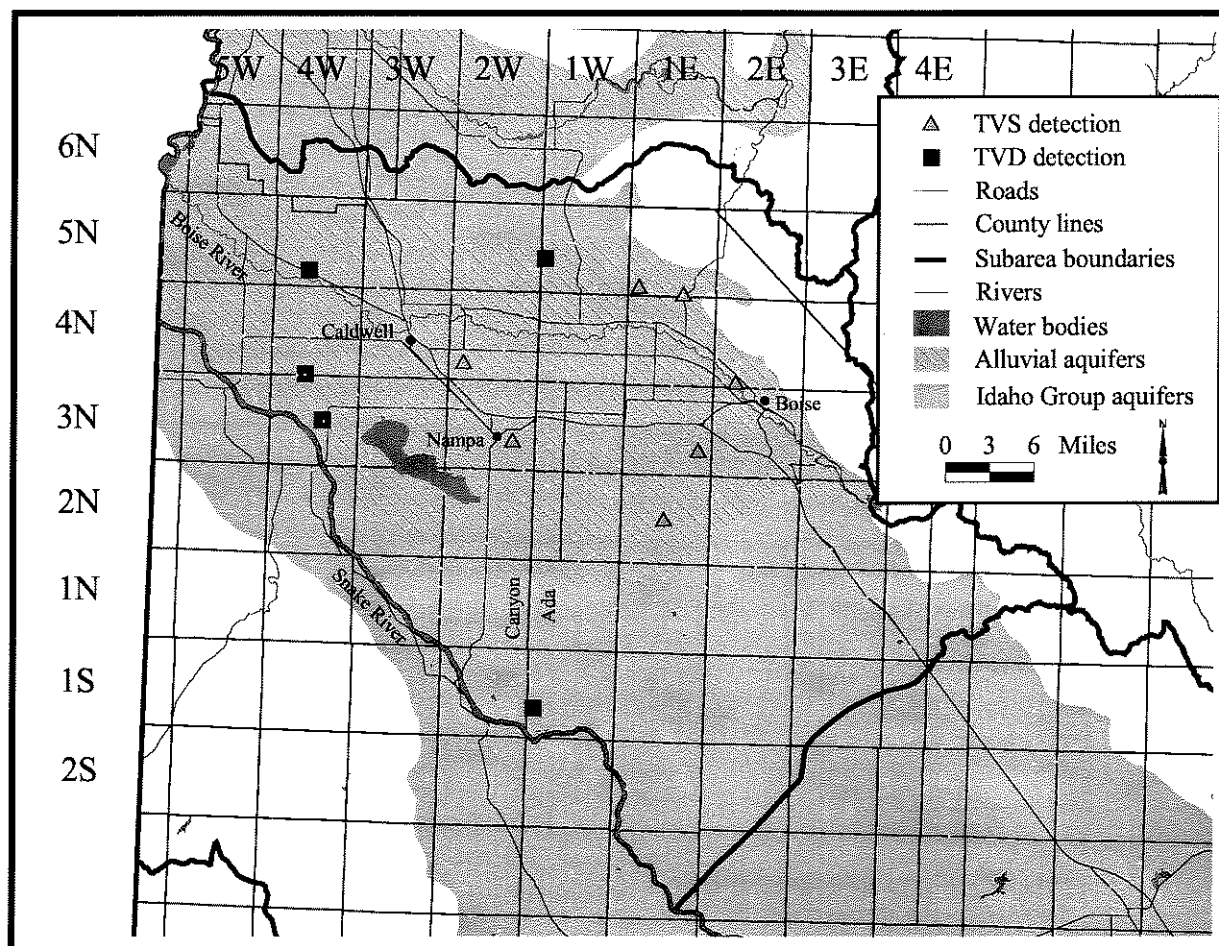


Figure 56. Fecal coliform bacteria detections for the Treasure Valley Shallow and Deep subarea, 1991-1994.

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## TREND MONITORING

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### Program Approach

The trend monitoring objective of the Statewide Program is being accomplished in two ways. First, about 1,200 monitoring sites called **Four Year** sites are being sampled once every four years. This approach will allow for wide areal coverage at a sampling frequency that is considered adequate for determining long-term changes in overall ground water quality. Second, about 100 sites called **Annual** sites are being sampled once every year to provide data for short-term trend analyses. The collection frequency at Annual sites may be useful for determining whether concentration changes are associated with long-term trends or are being affected by unique events or conditions such as precipitation extremes or trends.

The network of monitoring sites was developed from 1991 through 1994 when about 400 new sites were added during each of these four years. The sample collection that occurred during these years is called **First Round** sampling. The TVS and TVD subareas each received about 35 new monitoring sites annually during First Round sampling. The majority of sites were sampled only once; however, a few sites were sampled a second time prior to 1995. Prior to the 1995 field season, sites were designated as either **Four Year** or **Annual** sites. Most of the Four Year sites sampled in 1991, 1992 and 1993 were re-sampled in 1995, 1996 and 1997, respectively. The data collected from 1995 to 1997 at Four Year sites are called **Second Round** sampling. Some sites have not been re-sampled for a variety of reasons including non-representativeness of the site, missing lithologic or well construction data, non-use of the site or owner request. Second Round sampling will be completed when the 1994 sites are re-sampled in 1998. **Third Round** sampling is scheduled to begin in 1999. Most Annual wells had been sampled three or four times by the end of the 1997 field season.

The Statewide Program has endeavored to standardize on laboratories and analyses to facilitate comparisons. Second Round samples were analyzed for the same constituents and parameters (except mercury, cyanide and radon) using the same laboratory methods in all cases except for the volatile organic compounds. VOCs were analyzed by the Idaho State Health Laboratory in 1991 using EPA Method 502.2 and by the USGS laboratory in 1992 using EPA Method 524.2. VOC analyses were performed by Alpha Analytical Laboratory in Sparks, Nevada, using EPA Method 524.2 from 1993 through 1997 (Refer to Appendix C).

### Initial Trend Results - TVS and TVD

Trend data are currently limited to: 1) comparisons of First Round sampling (1991-

1993) to Second Round sampling (1995-1997), 2) time versus concentration graphs for Annual sites that have been sampled at least three times, and 3) comparisons of concentration changes for sites with multiple GC pesticide analyses. Only partial trend analyses were completed for this report because of limited trend data. Nitrate and TDS data were selected for trend analyses because they were considered to be possible indicators of short-term changes that may be related to land use activities. We estimate that sufficient trend data from Annual sites will be available by 1999 to begin more extensive trend analyses. Trend data collected from Four Year sites will probably be adequate for some trend analyses after the Third Round sampling is completed.

### First Round to Second Round Comparisons

Nitrate concentrations increased at 66 of the 92 TVS subarea sites (72 percent) sampled in 1991-1993, and re-sampled in 1995-1997. Individual increases ranged from 0.03 mg/l to 11.20 mg/l. The median nitrate value for the 92 paired TVS sites increased 0.52 mg/l from 3.35 mg/l (First Round) to 3.87 mg/l (Second Round). Nitrate concentrations decreased at 22 sites (24 percent) and remained unchanged at 4 sites (4 percent). The percentage of TVS subarea sites with nitrate concentrations equal to or greater than 2.0 mg/l increased from 70 percent for the First Round sampling to 73 percent for the Second Round sampling (Figure 57). The number of TVS sites with nitrate concentrations exceeding the MCL of 10 mg/l increased from 2 (First Round) to 7 (Second Round).

The Wilcoxon signed-rank test was used to analyze for significant differences between paired data from the First and Second Rounds. Differences between paired data will be

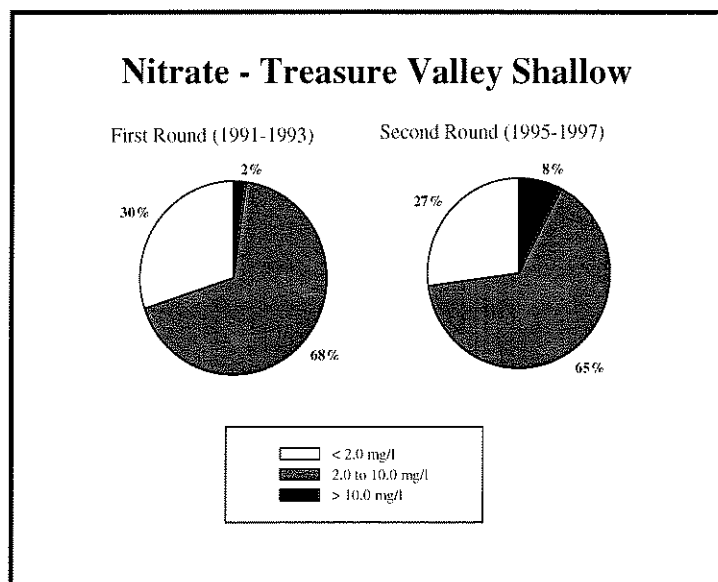


Figure 57. Pie graphs showing nitrate concentration percentages for the First and Second Round sampling for the Treasure Valley Shallow subarea.

approximately symmetrical (i.e., about half of the differences will be above zero and about half of the differences will be below zero) if the two groups are from the same or from an unchanged population (Helsel and Hirsch, 1992). A calculated probability (p) value equal to or less than 0.05 indicates that there is a significant difference between the two paired datasets at the 95 percent confidence level (i.e., for the Statewide Program data, there has been a significant change in concentrations (higher or lower) from one dataset to the other dataset).

Wilcoxon signed-rank test results for nitrate data at paired TVS sites indicated that there were

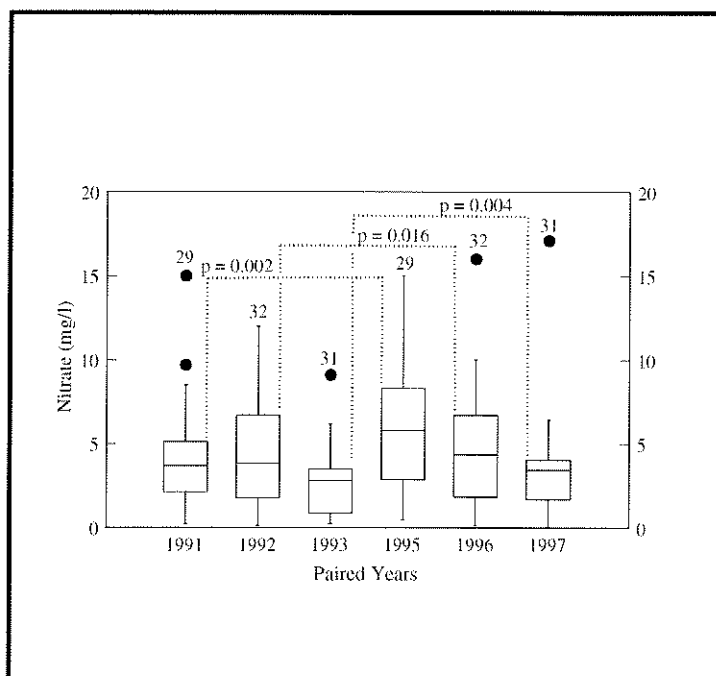


Figure 58. Boxplots and Wilcoxon signed-rank test results for nitrate versus paired sampling years for the Treasure Valley Shallow subarea.

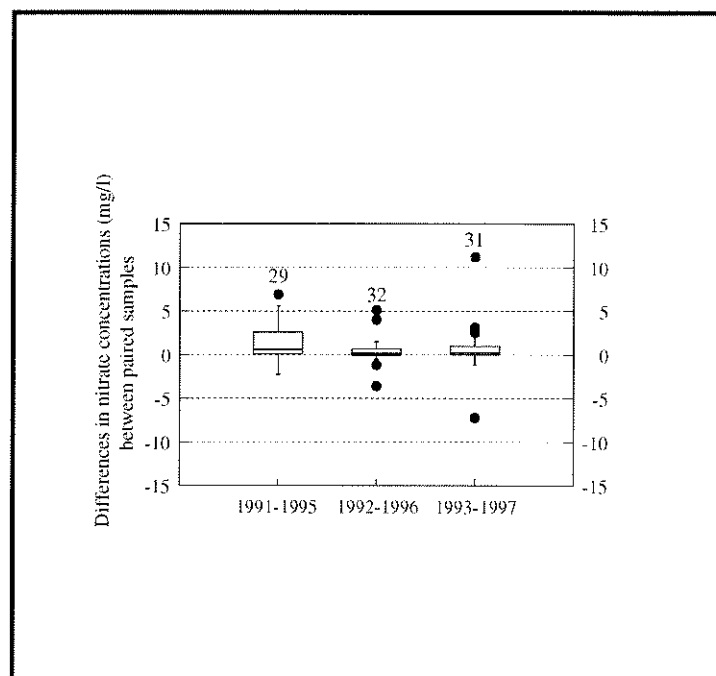


Figure 59. Boxplots of the differences in nitrate concentrations between paired samples versus years of sampling for the TVS subarea.

significant differences between the three datasets from the First Round and the three associated datasets from the Second Round at the 95 percent confidence level (Figure 58). The nitrate medians for all three paired datasets increased from the First Round to the Second Round. The Wilcoxon signed-rank test appears to be very sensitive to small differences since the overall change in medians from First Round to Second Round was only 0.52 mg/l. The differences in nitrate concentrations between the paired datasets were greater for 1991-1995 than for the other paired years (Figure 59).

Nitrate concentrations increased at 40 of the 79 TVD subarea sites (51 percent) sampled in 1991-1993, and re-sampled in 1995-1997. Nitrate concentrations decreased at 28 sites (35 percent) and remained unchanged at 11 sites (14 percent). Concentration changes ranged from -7.20 mg/l to 6.42 mg/l. The median nitrate value decreased from 0.87 mg/l for the First Round to 0.69 mg/l for the Second Round. Wilcoxon signed-rank test results indicated that there were no significant differences between the three paired datasets at the 95 percent confidence level.

The reason(s) for the increases in nitrate concentrations, especially in the TVS subarea sites, is unknown. One factor that may have contributed to some of the concentration increases is precipitation. The average

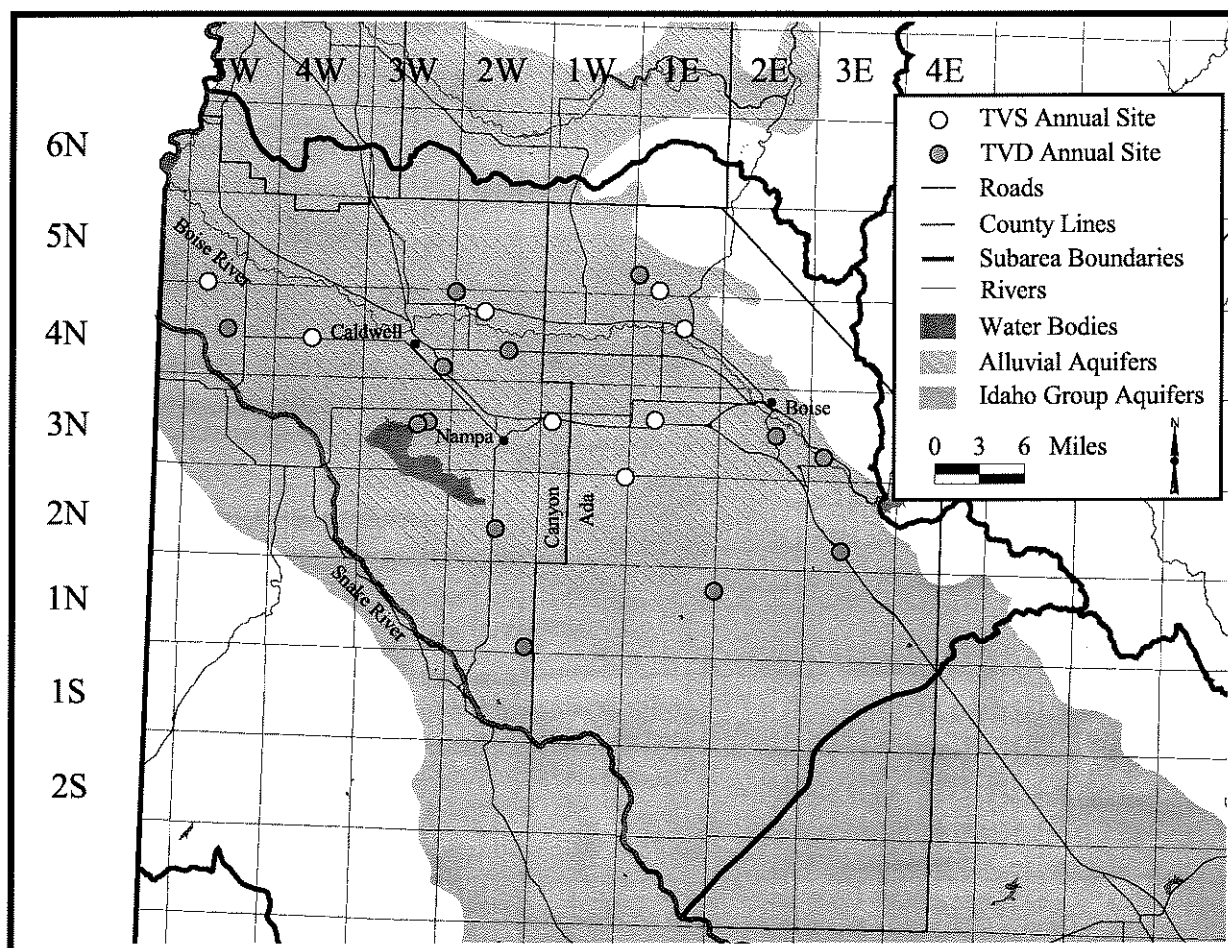


Figure 60. Annual sites for the Treasure Valley Shallow and Treasure Valley Deep subareas.

precipitation for the three gauging stations in the Treasure Valley was about 50 percent higher for 1995 and 1996 (Second Round) than for 1991 and 1992 (First Round). It appears that the precipitation for 1997 will also be higher than it was in 1993. Higher precipitation may increase the downward percolation of nitrates that accumulated in the soil during low precipitation years.

TDS data from 1991 and 1992 (First Round) and from 1995 and 1996 (Second Round) for both the TVS and TVD subareas were analyzed for trends. TDS data from 1997 were not available at the time this report was written. Wilcoxon signed-rank test results indicated that there were no significant differences at the 95 percent confidence level between the paired datasets (1991-1995 and 1992-1996) for the TVS subarea and between the paired datasets (1991-1995) for the TVD subarea. However, the 1992-1996 paired data for the TVD subarea were significantly different at the 95 percent confidence level. TDS concentrations decreased at 18 of the 24 TVD sites (75 percent) sampled in both 1992 and 1996. The median TDS value decreased from 314 mg/l (1992) to 275 mg/l (1996). The overall change in TDS median values for the TVD subarea was from 275 mg/l (First Round) to 259 mg/l (Second Round).

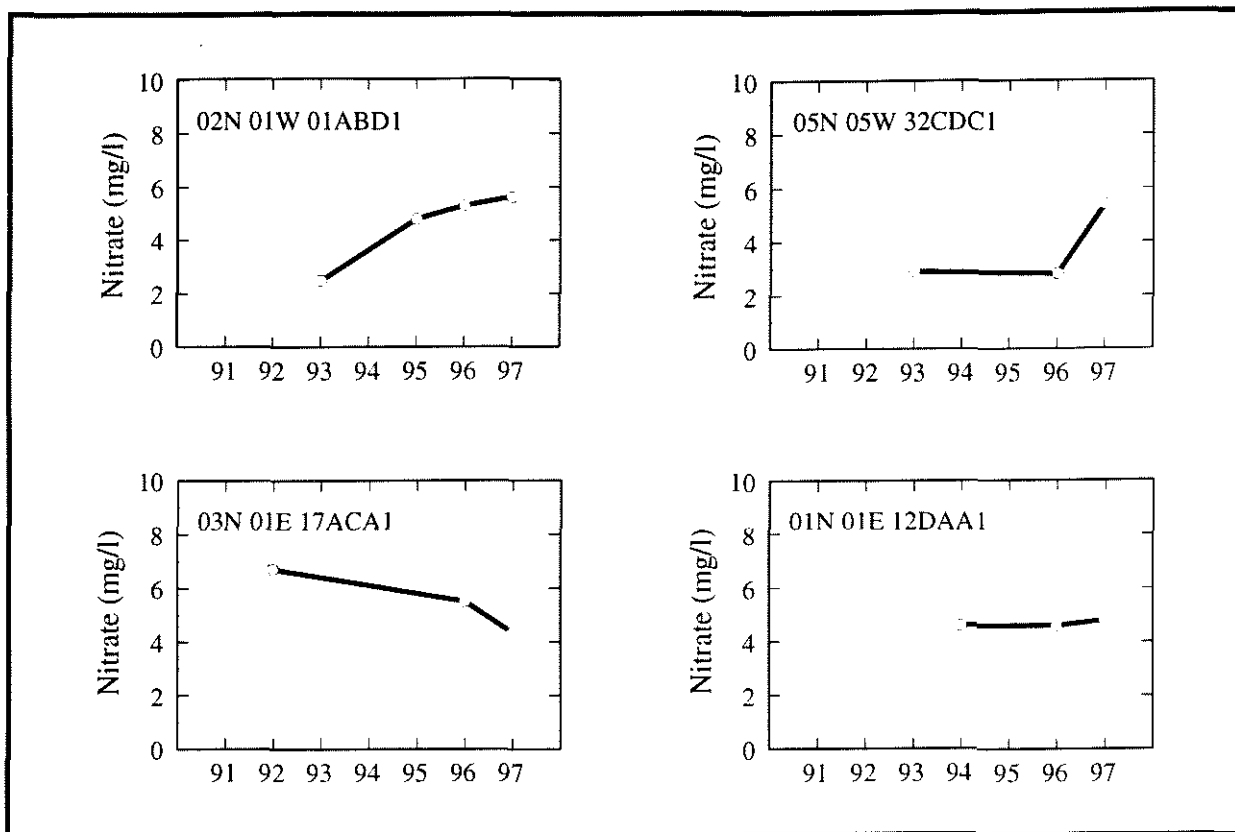


Figure 61. Four examples from Annual wells in the Treasure Valley showing nitrate concentrations versus time.

#### Results from Annual Sites

The numbers of Annual sites for the TVS and TVD subareas are 8 and 13, respectively (Figure 60). Most of the 21 Annual sites in the Treasure Valley Shallow and Deep subareas had only three years of water quality data at the end of the 1997 field season. Preliminary interpretations of the data for the Treasure Valley annual sites suggest that nitrate concentrations increased at nine sites (average increase equaled 1.50 mg/l), decreased at five sites (average decrease equaled 1.00 mg/l) and remained constant at seven sites (Figure 61). Five of the eight TVS annual sites (63 percent) had increases in nitrate concentrations; four of the 13 TVD annual sites (31 percent) showed increased nitrate levels. Statistical trend analyses at the Treasure Valley annual sites may be possible after two or three more sampling events.

#### Sites with Multiple GC Pesticide Analyses

Three sites in the TVS subarea had GC pesticide detections in 1995, 1996 and 1997. The pesticide compounds found in the samples in 1995 and several additional compounds were detected in the 1996 and 1997 samples (Table 4).

Table 4. Results from three TVS subarea sites with GC pesticide detections in 1995, 1996 and 1997.

Station	Compounds detected in 1995	Compounds detected in 1996	Compounds detected in 1997
02N 01W 01ABD1	atrazine (0.040 $\mu\text{g/l}$ ) deethylatrazine (0.033 $\mu\text{g/l}$ )	atrazine (0.059 $\mu\text{g/l}$ ) deethylatrazine (0.051 $\mu\text{g/l}$ ) simazine (0.005 $\mu\text{g/l}$ )	atrazine (0.042 $\mu\text{g/l}$ ) deethylatrazine (0.040 $\mu\text{g/l}$ ) simazine (0.006 $\mu\text{g/l}$ )
04N 04W 21CAA2	atrazine (0.002 $\mu\text{g/l}$ )	atrazine (0.003 $\mu\text{g/l}$ ) deethylatrazine (0.003 $\mu\text{g/l}$ )	atrazine (0.004 $\mu\text{g/l}$ ) carbaryl (0.023 $\mu\text{g/l}$ ) deethylatrazine (0.003 $\mu\text{g/l}$ )
05N 01E 32DBD1	atrazine (0.064 $\mu\text{g/l}$ ) deethylatrazine (0.042 $\mu\text{g/l}$ )	atrazine (0.056 $\mu\text{g/l}$ ) chlorpyrifos (0.004 $\mu\text{g/l}$ ) deethylatrazine (0.028 $\mu\text{g/l}$ ) metolachlor (0.004 $\mu\text{g/l}$ ) simazine (0.005 $\mu\text{g/l}$ )	atrazine (0.041 $\mu\text{g/l}$ ) deethylatrazine (0.018 $\mu\text{g/l}$ ) simazine (0.004 $\mu\text{g/l}$ )

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## GROUND WATER QUALITY CONCERNS

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The third program objective of the Statewide Program is to identify potential problem areas. The Statewide Program monitoring network was designed primarily to address overall ambient ground water quality and consequently the density of sites is not adequate to define and delineate regional ground water quality problems, or to screen for all possible pockets of local contamination. However, the data and interpretations can be used to indicate where there are sites and/or areas of concern that may warrant follow-up investigations.

Most of the Statewide Program sites in the Treasure Valley had ground water quality that was suitable for human consumption and other beneficial uses. However, 49 of the 281 monitoring sites (17 percent) had one or more constituents with concentrations that exceeded the primary MCLs as established by the EPA for public drinking water supplies (MCLs have been adopted by Idaho as Ground Water Rules (IDAPA 16.01.11.400.03)). The percentage of detections exceeding MCLs for the Treasure Valley was higher than the overall statewide result of 10 percent. The number of detections exceeding MCLs was 33 for the TVS subarea (23 percent) and 16 for the TVD subarea (12 percent). Ground water quality concerns in the Treasure Valley were also apparent either by the presence of organic compounds or by constituent concentration levels.

Ground water quality concerns in the Treasure Valley Shallow and Deep subareas occurred as either concentrations that were: 1) most likely related to natural conditions, or 2) probably associated with human activities. Potential sources of elevated constituent concentrations and the health or other significances are listed in Appendix B.

### **Naturally Occurring**

Fluoride, sulfate, arsenic, gross alpha and gross beta radiation, uranium, radium and radon are the constituents that were detected in the ground water of the Treasure Valley subareas that may be of concern to human health and that are likely to be related to natural conditions.

#### Fluoride

One site in the TVD subarea (01N 03W 08BDB1) had a fluoride concentration of 16.0 mg/l which was four times the primary MCL of 4.0 mg/l. Three other sites in TVD subarea (02N 02W 22CCA1, 04N 04W 04CDC1 and 05N 01E 26DCD1) had concentrations between 2.0 mg/l, which is the secondary MCL, and 4.0 mg/l. The four sites do not appear to be related geographically or hydrogeologically. None of the sites in the TVS subarea had fluoride concentrations that exceeded 2.0 mg/l.

The site with the fluoride concentration of 16.0 mg/l fluoride had a geothermal water temperature (31.7° C). The site was initially included in the network because there were no TVD subarea cold water wells in the vicinity of the selection and because the warm water in this area is being used for domestic purposes. Other wells in the vicinity may also be at risk of high fluoride concentrations, as are other areas in Idaho where non-geothermal ground water is affected by geothermal water. This site will not likely be sampled in the future because it is more representative of the geothermal aquifer than the TVD subarea.

### Sulfate

Two sites in the TVD subarea had sulfate concentrations that exceeded the proposed primary MCL of 400 or 500 mg/l. Seven sites in the TVD subarea and two sites in the TVS subarea had sulfate concentrations that exceeded the secondary MCL of 250 mg/l. Most of these sites occurred in areas southwest and west of Caldwell and south of Nampa. The sulfate concentrations may be related to geothermal influence.

### Arsenic

Arsenic in the ground water is a concern in areas west of Nampa and Caldwell where five sites had arsenic concentrations greater than the MCL of 50 µg/l. An additional eleven sites in the TVS subarea and seven sites in the TVD subarea in the same general area had arsenic concentrations between 25 and 50 µg/l (Figures 43, 44 and 45). It is unknown whether the cause for the high arsenic concentrations is anthropogenic (historic pesticide use), geologic or a combination of sources.

### Alpha Radiation, Uranium and Radium

Twenty-three of the 281 monitoring sites (8 percent) had adjusted gross alpha radioactivity concentrations that exceeded the MCL of 15 pCi/l. Elevated gross alpha detections occurred throughout the two subareas with some discernable patterns noted previously (Figures 48 and 49). The number of sites with concentrations over the MCL was about three times greater for the TVS subarea than for the TVD subarea.

Ground water samples from 43 sites were speciated for total uranium and radium-226 to determine the source of the alpha radiation. Thirty-three of the 43 samples had total uranium concentrations that exceeded the proposed MCL of 20 µg/l and two samples had radium-226 values that exceeded the current MCL of 5.0 pCi/l. Uranium detections occurred throughout the Treasure Valley (Figure 50); however, more data are needed to discern patterns of occurrence. The source of the two high radium-226 detections, whether natural or human-caused, is unknown. Furthermore, the areal extent of the high radium-226 appears to be limited and the two sites are unrelated (one is located southeast of Boise; the other is located southwest of Nampa near Lake Lowell). These two sites are of concern because the values are so unusual (much higher than the surrounding data); follow-up monitoring appears to be warranted.



### Beta Radiation

One of the 281 sites (03N 01E 14BBD1) had a total gross beta detection that exceeded the primary MCL of 50 pCi/l. Two other sites (03N 01W 05BAA1 and 03N 01E 21DCA1) showed gross beta activities that were near the MCL. All three sites are located between Boise and Nampa. Results for specific beta emitters are not available for these samples.

### Radon

One of the 189 sites tested for radon had a concentration that exceeded 3,000 pCi/l. The site, which was in the TVS subarea in an area west of Caldwell, had a radon radioactivity concentration of 3,700 pCi/l. Eleven other sites (six in the TVS and five in the TVD) exceeded 1,500 pCi/l. Seven of these 11 sites were located in eastern and southeastern parts of the Treasure Valley. The significance of the level of radon radioactivity in the ground water is not known because there are many factors that can contribute to airborne radon (the primary health concern from radon). However, since the data clearly show that the highest radon concentrations in ground water occur in the east and southeast portion of both subareas, it is probable that the highest potential for airborne radon activities is in the same areas.

### **Human Activities**

Bacteria, nitrate, ammonia, phosphorus, volatile organic compounds and pesticides were the constituents detected in the ground water of the Treasure Valley that may be of concern to human health or the environment and that are most likely related to human activities. Eighty-three percent of the TVS sites and 49 percent of the TVD sites had at least one constituent related to human activities with a concentration that either exceeded an MCL or had a concentration at a level of concern (Figures 62 and 63). Clearly, the ground water quality of the TVS subarea has been impacted more by human activities than the ground water quality of the TVD subarea.

### Bacteria

Fecal coliform bacteria were detected in the ground water from 12 wells (4 percent). The detections occurred throughout the subarea following no particular pattern. Further investigations are needed to determine if the presence of fecal coliform bacteria in the ground water is related to well construction problems and/or to other factors such as septic systems or livestock operations.

### Nitrate

Nitrate in ground water is often used as a qualitative and quantitative yardstick to measure how much impact has occurred to the water quality from land surface activities. Nine sites in the TVS and TVD subareas (three percent) had nitrate concentrations that exceeded the

MCL. One hundred and thirty-six sites (48 percent) had nitrate concentrations between 2.0 and 10.0 mg/l indicating that impact to the ground water has occurred extensively. Compared to the TVD subarea, the TVS subarea had about twice the number of sites with nitrate detections above the MCL and about twice the number of sites with concentrations from 2.0 to 10.0 mg/l. Nitrate concentrations decreased with increased well depth as indicated by Spearman's rho analyses. The median nitrate value for the agriculture land use category was significantly higher than the median value for the urban category at the 95 percent confidence levels. Other factors, such as well construction, type of source, source loading and the distance from the nitrate source to the well need to be investigated to determine if they influenced the nitrate concentrations.

Another observation of concern is the increase in nitrate concentrations from First Round samples (1991-1993) to Second Round samples (1995-1997) for the TVS subarea. Sixty-six of the 92 paired samples had increases in nitrate levels with the increase in the medians being 0.52 mg/l from First Round to Second Round. Individual increases ranged from 0.03 mg/l to 11.20 mg/l. The number of TVS sites with nitrate concentrations greater than the MCL of 10 mg/l increased from two in the First Round to seven in the Second Round. Second Round sampling will be completed when the 1994 sites are re-sampled in 1998.

### Ammonia

Ammonia is a nitrogen compound that is: 1) produced by the decay of organic matter (Hem, 1991), 2) the primary nitrogen compound in animal and human waste, and 3) a common nitrogen fertilizer (typically as anhydrous ammonia and urea). Ammonia is converted rapidly to nitrate or nitrite if oxygen is available. The presence of ammonia in ground water is an indication that one or more of the following conditions exist: 1) decaying organic matter is moving from the land surface to the ground water rapidly, 2) the ground water has insufficient oxygen for converting the ammonia to nitrate or nitrite, or 3) decaying organic material in the soil and/or aquifer materials is providing ammonia to the system.

Elevated concentrations of ammonia may cause concerns in parts of the Treasure Valley because: 1) it can convert to nitrate, and 2) it may be an indicator of waste paths to the ground water that could also transport pathogens. Fourteen sites in the TVD subarea and two sites in the TVS subarea had ammonia concentrations equal to or greater than 1.0 mg/l (Figure 38). The highest ammonia concentration was 5.8 mg/l. The anomalous occurrences of high ammonia concentrations may warrant a follow-up regional and/or local study.

### Phosphorus

The highest orthophosphorus concentration which was 1.6 mg/l in a TVS well (32 feet deep). The source of the phosphorus may be a nearby City of Boise sewage treatment plant. Twenty-eight sites in the TVS subarea and 11 sites in the TVD subarea had orthophosphorus concentrations equal to or greater than 0.1 mg/l which is the considered the upper limit for preventing nuisance growths of algae and plants in moving surface waters (Mackenthun, 1969).

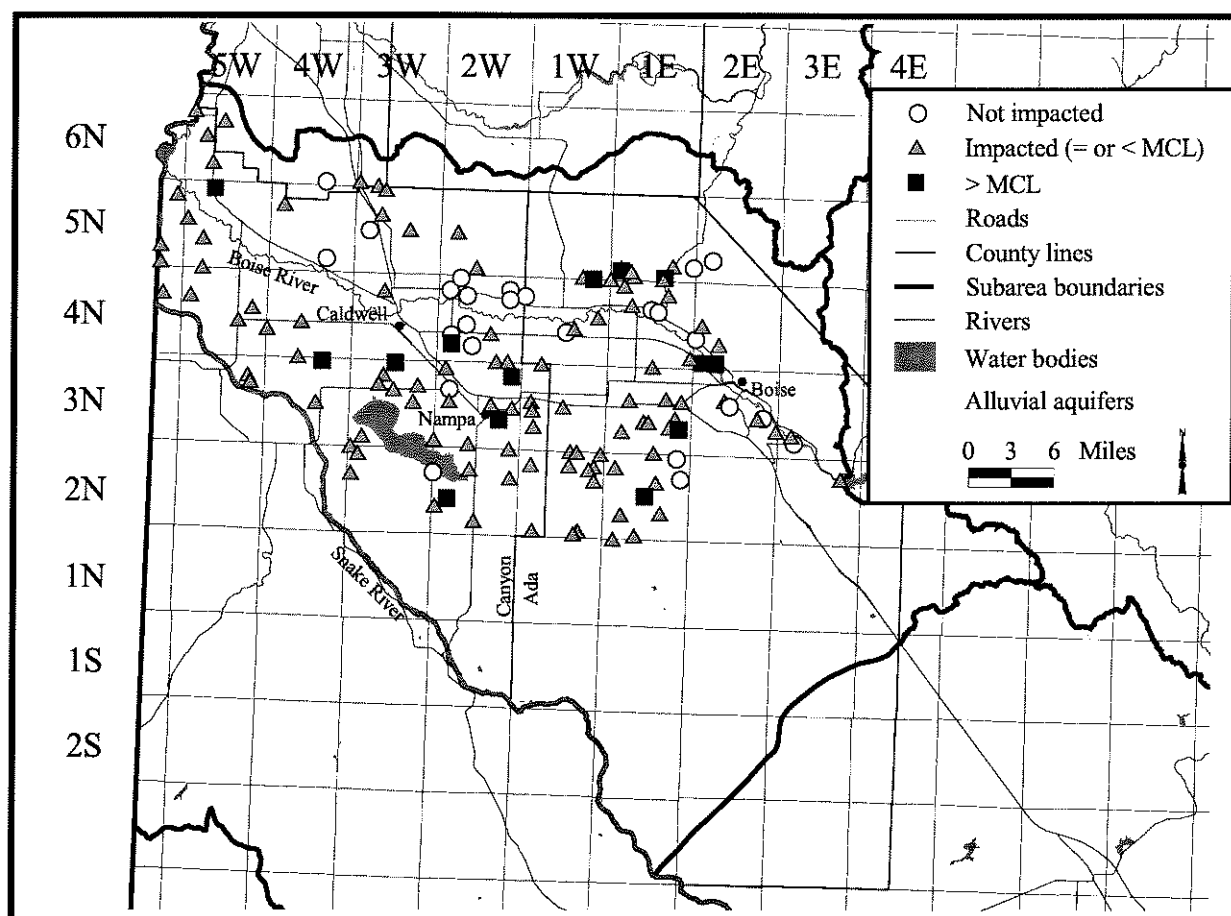


Figure 62. Human-induced ground water quality impacts and MCL exceedances for ammonia, bacteria, nitrate, pesticides, phosphorus and volatile organic compounds for the TVS subarea.

### Volatile Organic Compounds

VOCs have been detected in the ground water throughout the Treasure Valley with the most widespread and highest concentration occurrences found in the Boise urban area (Boyle, 1995, 1996). The network design for the Statewide Program is not adequate to screen for the type of VOC contamination that occurs in localized areas, generally from industrial sources. In fact, the Statewide Program would have missed most of the currently-identified VOC plumes in the Treasure Valley due to their limited areal extent. Comprehensive VOC investigations must be conducted by other programs that have higher densities of sites in areas with known or suspected VOC contamination.

Eleven Treasure Valley sites had certain detections of VOCs. Five of these detections were pesticide compounds (dichloropropane and trichloropropane) and six were probably related to industrial releases (four of the six were perchloroethylene). Two of the 11 detections

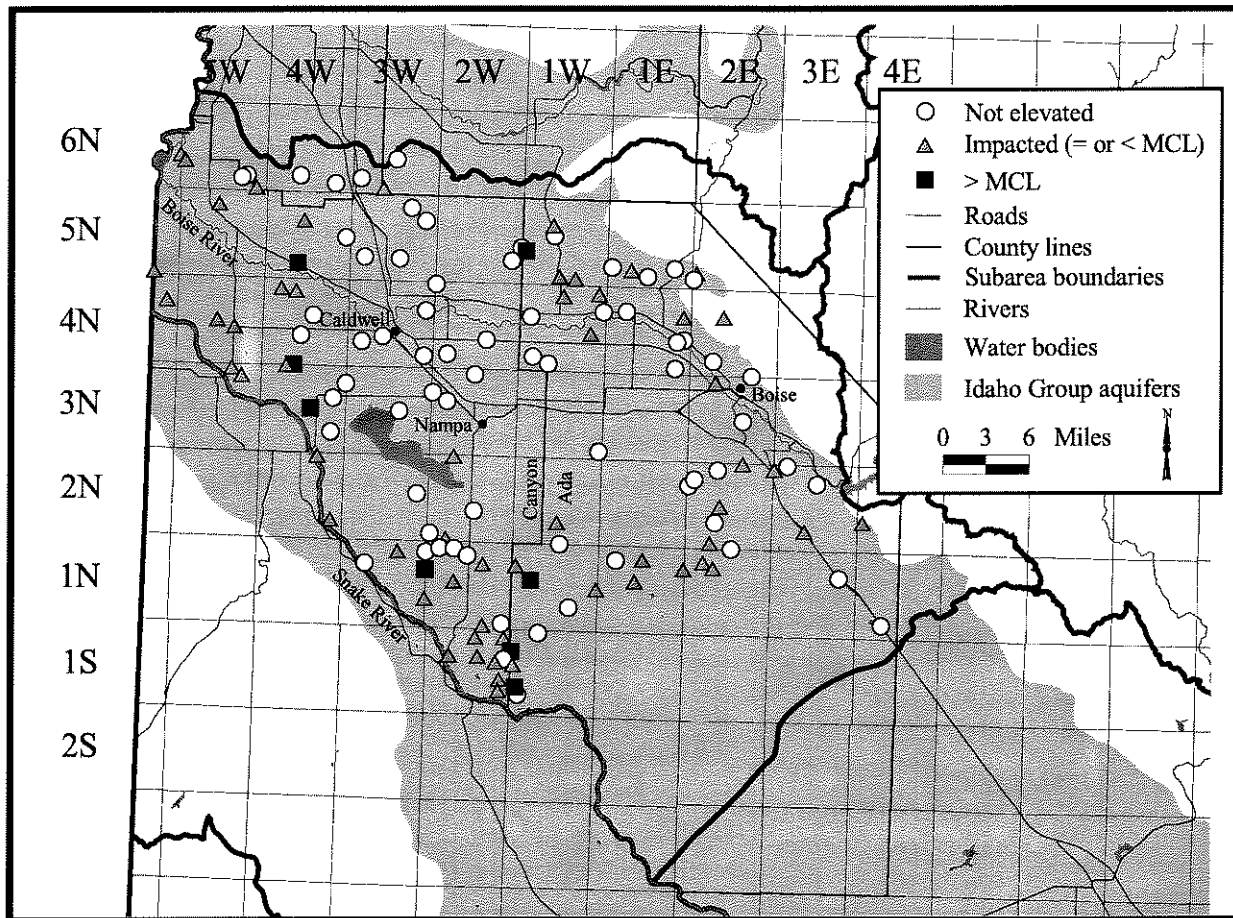


Figure 63. Human-induced ground water quality impacts and MCL exceedances for ammonia, bacteria, nitrate, pesticides, phosphorus and volatile organic compounds for the TVD subarea.

exceeded an MCL. The presence of any detection of these compounds indicates that human land use activities have impacted ground water quality and that follow-up monitoring, if not already underway, is warranted to determine the extent and concentration levels of the compound(s).

### Pesticides

Statewide program data showed that the ground water quality in the TVS subarea has been impacted by pesticides. Although concentration levels were low (generally, at least one order of magnitude below MCLs or Health Advisories), the percentage of detections was significant. Twenty-three percent of the sites tested by immunoassay and 84 percent of the sites tested by the GC method that measures in the parts per trillion range had detections. These results warrant further investigation through regional or local monitoring efforts. The ISDA has already conducted follow-up GC analyses at many of the sites with immunoassay detections.

The ISDA also conducted several detailed studies of pesticides and nutrients in an area north of Eagle where three Statewide Program sites showed pesticide detections (dichloropropane and trichloropropane) via VOC analyses (Whitney and others, 1992; Boyle, 1997).

The TVD subarea is also susceptible to impact from pesticides as indicated by the immunoassay tests where four percent of the samples had at least one pesticide detected. A limited number of GC analyses have been performed for the TVD subarea to date. Additional GC work seems warranted based on immunoassay results and on the fact that three of the 18 TVD subarea sites (17 percent) tested by GC had pesticide detections.



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## FUTURE PLANS

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The plans for future monitoring and data analyses for the Treasure Valley (and the responsible entities) are:

1. Continue to sample all Four Year and Annual sites according to their specific time schedules (IDWR and USGS).
2. Determine if the numbers of Annual sites currently in the TVS and TVD subareas are sufficient for short-term trend analyses (IDWR and the Trend Monitoring Technical Committee).
3. Conduct more comprehensive trend analyses as data become available (IDWR).



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## RECOMMENDATIONS

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The authors believe that the following recommendations, if enacted, will significantly enhance the understanding of the aquifer systems, ground water quality and land use relationships in the Treasure Valley. The possible responsible entities are listed in parentheses.

1. Collect samples from all of the Treasure Valley monitoring sites for pesticide analyses using the gas chromatography laboratory method with the laboratory detection limit in the parts per trillion. The preferred approach would be to sample all of the Treasure Valley sites in one year. An alternate approach would be to sample all of the TVS sites in one year and all of the TVD sites in the following year. This effort will require a significant increase in field work and funding for sample collection and laboratory analyses (IDWR, ISDA, DEQ and USGS).
2. Add dissolved oxygen as a field parameter to help determine oxidizing and reducing conditions (IDWR, TVHP and USGS).
3. Calibrate ground water vulnerability maps with nitrate, pesticide and possibly arsenic data. The calibration should be done at 1:24,000 scale, if possible (TVHP and USGS).
4. Delineate stratigraphic relationships and flowpaths through the use of ground water chemistry data. Determine the degree and extent of hydrologic connections or separations between the Idaho Group and the Snake River Group (IDWR and TVHP).
5. Investigate relationships between land use activities and the occurrences of contaminants such as arsenic, nitrate, pesticides, volatile organic compounds and bacteria in the ground water (DEQ, ISDA and USGS).
6. Determine if regional and local follow-up studies are needed for sites and areas with: 1) detections of bacteria, pesticides and VOCs, and 2) elevated concentrations of ammonia, arsenic, fluoride, gross alpha and nitrate. Prioritize and conduct the studies (DEQ and ISDA).
7. Encourage the use of Statewide Program data for university student research projects. An example of a possible project would be the investigation of the occurrence of elevated ammonia in the TVD subarea (IDWR and universities).



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## SUMMARY AND CONCLUSIONS

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The Treasure Valley, which is located in Ada and Canyon counties of southwestern Idaho, is a depositional basin in the western part of the Snake River Plain. The cold water aquifer systems of the Treasure Valley were stratified into two hydrogeologic subareas: the Treasure Valley Shallow (TVS) and the Treasure Valley Deep (TVD). Ground water quality data collected from 1991 through 1997 showed that water chemistries between the two subareas were significantly different thus confirming the stratification approach. However, the degree and extent of the hydrologic connections or separations between the two systems are unknown.

The water chemistry for the TVD subarea was more variable than the chemistry for the TVS subarea. The dominant water types for both subareas were calcium-bicarbonate and sodium-bicarbonate. The ground water of the TVS subarea had higher mineralization than the ground water of the TVD subarea as indicated by the concentrations of TDS, hardness and most ions. TDS concentrations were definitely higher in the southcentral and western parts of the TVD subarea. Patterns for TDS concentrations in the TVS subarea were not discernable except for the common occurrence of low TDS values near the Boise River.

The data indicated that most of the Statewide Program sites had ground water quality that was suitable for human consumption and other beneficial uses. However, 49 of the 281 monitoring sites in the TVS and TVD subareas (17 percent) had one or more constituents with concentrations that exceeded the primary MCLs as established by the EPA for public drinking water supplies. The percentage of MCL exceedances for the Treasure Valley was higher than the overall statewide result of 10 percent. The number of MCL exceedances was 33 for the TVS subarea (23 percent) and 16 for the TVD subarea (12 percent). The constituents with concentrations greater than, their respective MCLs were arsenic, bacteria, fluoride, gross alpha, gross beta, nitrate and volatile organic compounds. Clearly, ground water quality in parts of the Treasure Valley is affected naturally or has been impacted by human activities.

Eighty-three percent of the TVS sites and 49 percent of the TVD sites had at least one constituent with a concentration that appeared to be impacted by human land use activities. Ammonia, bacteria, nitrate, pesticides, phosphorus and volatile organic compounds were detected at levels either greater than the MCL or at concentrations that would not occur naturally. Further study is needed to determine the effects of land use, ground water vulnerability and hydrogeology on ground water quality impacts in the Treasure Valley.

Trend analysis, which is currently in its initial stages for the Statewide Program, will be critical for determining if, and how fast, the ground water quality is degrading in the Treasure Valley. Initial trend results indicated that nitrate concentrations increased at 66 of the 92 TVS subarea sites that were sampled during the First Round (1991-1993) and re-sampled during the



Second Round (1995-1997). Second Round sampling will be completed when the 1994 sites are re-sampled in 1998.

*Continued Statewide Program monitoring in the Treasure Valley is needed due to the high percentage of MCL exceedances, the initial trend results for nitrate, the number of pesticide and VOC detections, and the rapid growth and development in this part of the state. Regional and local follow-up studies will be also important for ascertaining the extent of contamination detected by the Statewide Program and by other historical and on-going ground water quality projects in the Treasure Valley.*





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**APPENDIX A**  
**Treasure Valley Shallow Subarea**

Constituent Percentiles

Constituent	Min.	10%	25%	50%	75%	90%	Max.
Specific Conductance	111	228	348	613	758	948	1532
Temperature °C	11	13	13.6	14.6	15.5	16.6	24.9
pH	6.4	7.0	7.3	7.6	7.8	7.9	8.6
Alkalinity	52	82	132	214	266	309	440
Hardness (mg/l)	41	76	120	195	240	287	417
Calcium (mg/l)	12	21	36	50	62	78	100
Magnesium (mg/l)	2.6	4.9	7.8	14	22	26	48
Sodium (mg/l)	5.7	13	22	49	74	110	180
Potassium (mg/l)	0.6	1.3	1.9	2.9	4.7	7.0	15
Bicarbonate (mg/l)	63	101	160	257	325	375	537
Sulfate (mg/l)	<0.10	9	21	54	96	153	280
Chloride (mg/l)	0.20	2.6	6	13	26	48	170
Fluoride (mg/l)	0.10	0.20	0.30	0.50	0.62	0.80	1.20
Silica (mg/l)	16	28	32	40	54	60	73
Nitrate (mg/l)	<0.05	0.46	1.2	2.9	5.1	8.0	22
Ammonia (mg/l)	<0.01	<0.01	<0.01	0.01	0.02	0.04	2.6
Phosphorus (mg/l)	<0.01	<0.01	0.02	0.04	0.08	0.19	1.6
Total Dissolved Solids (mg/l)	82	163	230	395	499	615	956
Arsenic (µg/l)	<1	1	2	6	16	28	130
Cadmium (µg/l)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chromium (µg/l)	<1	<1	<1	<1	1	2	10
Copper (µg/l)	<1	<1	<1	1	2	6	65
Iron (µg/l)	<3	<3	<3	4	7	23	4200
Lead (µg/l)	.1	<1	<1	<1	<1	<1	2
Manganese (µg/l)	<1	<1	<1	<1	1	8	1300
Selenium (µg/l)	<1	<1	<1	<1	1	2	8
Zinc (µg/l)	<3	3	8	18	46	103	460
Cyanide (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Adj. Gross Alpha (pCi/l)*	0	0.7	1.8	5.4	10.3	17.1	56.9
Gross Beta (pCi/l)	0.7	2.8	4.1	8.6	12.9	20.5	57.4
Radon (pCi/l)	210	352	460	590	880	1242	3700

\*Adjusted gross alpha does not include uranium. See radioactivity section for a discussion of uranium concentrations.

# **APPENDIX A** **Treasure Valley Deep Subarea**

## Constituent Percentiles

Constituent	Min.	10%	25%	50%	75%	90%	Max.
Specific Conductance	119	196	268	372	680	942	2030
Temperature °C	12.9	14.7	15.9	18.1	21.4	24.0	31.5
pH	6.9	7.2	7.5	7.8	8.0	8.2	8.9
Alkalinity	50	73	100	130	190	256	345
Hardness (mg/l)	6	42	68	112	179	323	720
Calcium (mg/l)	2.4	14	19	32	50	82	160
Magnesium (mg/l)	0.04	1.7	3.3	6.6	14	24	90
Sodium (mg/l)	7.9	14	20	41	63	84	230
Potassium (mg/l)	0.80	1.2	1.7	2.8	5.7	12	29
Bicarbonate (mg/l)	61	89	120	157	235	312	421
Sulfate (mg/l)	<0.10	5.4	15	32	92	190	570
Chloride (mg/l)	0.40	2.6	5.3	10	24	51	180
Fluoride (mg/l)	<0.10	0.20	0.30	0.40	0.60	0.90	16
Silica (mg/l)	17	27	32	38	50	66	83
Nitrate (mg/l)	<0.05	<0.05	0.06	0.80	2.6	5.3	21
Ammonia (mg/l)	<0.01	<0.01	<0.01	0.02	0.12	1.14	5.8
Phosphorus (mg/l)	<0.01	<0.01	0.01	0.02	0.04	0.08	0.23
Total Dissolved Solids (mg/l)	88	141	186	246	453	615	1370
Arsenic (µg/l)	<1	1.6	3.0	5.0	10	19	62
Cadmium (µg/l)	<1.0	<1.0	<1.0	>1.0	<1.0	<1.0	<1.0
Chromium (µg/l)	<1	<1	<1	<1	2	4	21
Copper (µg/l)	<1	<1	<1	<1	1	3	29
Iron (µg/l)	<3	<3	<3	6	34	158	1400
Lead (µg/l)	<1	<1	<1	<1	<1	<1	4
Manganese (µg/l)	<1	<1	<1	1.0	49	160	920
Selenium (µg/l)	<1	<1	<1	<1	1	2	6
Zinc (µg/l)	<3	<3	<3	11	41	104	610
Cyanide (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Adj. Gross Alpha (pCi/l)*	0	0.1	0.6	1.5	3.8	9.2	29.2
Gross Beta (pCi/l)	0.3	1.7	2.6	4.8	10	17	27.7
Radon (pCi/l)	<80	229	342	440	658	1011	1800

\* Adjusted gross alpha does not include uranium. See radioactivity section for a discussion of uranium concentrations.



## APPENDIX B

### SOURCE and SIGNIFICANCE of CONSTITUENTS

Constituent	Potential Sources	Standards or Categories	Significance
Bacteria	Sewage, animal or human	'No total coliform' primary MCL	The presence of total or fecal coliform bacteria is an indicator of the potential presence of harmful bacteria. Harmful bacteria may cause illness (i.e. cramps or flu-like symptoms) or death.
Hardness	Natural conditions. Measure of calcium and magnesium.	<75 soft 75 to 150 hard 151 to 300 moderately hard >300 very hard	Calcium and magnesium are essential to health. Hardness causes mineral deposits on plumbing, fixtures and windows, and decreases the sudsing capacity of soap.
Sulfate	Natural conditions, liquid and atmospheric industrial waste.	250 mg/l secondary MCL 400 to 500 mg/l primary MCL (proposed)	May impart bitter taste to water, scale in boilers. At higher levels may cause diarrhea, dehydration and gastroenteritis, organ or duct calculi (concretion of mineral salts).
Chloride	Natural conditions, sewage, industrial wastes, water purification.	250 mg/l secondary MCL	Produces undesirable taste in water. Increases corrosiveness of water.
Fluoride	Natural conditions, use or manufacture of fertilizers, industrial waste, some public water supplies.	2.0 mg/l secondary MCL. 4.0 mg/l primary MCL.	Beneficial at low levels. Over 2 mg/l may cause teeth mottling in children. Over 4 mg/l over a period of time may cause crippling skeletal fluorosis in adults, resulting in brittle bones, kidney damage and possibly nerve and muscle damage.
Total Dissolved Solids	Measure of all dissolved solids, usually common ions.	500 mg/l secondary MCL	Indicates level of mineralization. Some minerals may negatively affect taste, corrosiveness, mineral build-up or health.

Primary and secondary standards are established by the USEPA for regulation of public drinking water supplies. MCL=maximum allowable contaminant level. Secondary MCLs are suggested for non-health related, aesthetic concerns such as taste, odor, color and mineral buildup. Primary MCLs are established for health related concerns.

Constituent	Potential Sources	Standards or Categories	Significance
Arsenic	Natural conditions, pesticides, industrial waste. Largest source of intake is generally food, esp. seafood.	50 µg/l primary MCL (under review)	Organic forms are handled easily by the body. High levels of inorganic forms may cause gastrointestinal problems, changes in nails, abnormal skin thickening or pigment and blood vessel damage. Skin cancer and nerve damage may occur with long term exposure.
Cadmium	Mineral deposits, corrosion of galvanized pipes, industrial/mining waste, batteries/landfills. Most common from tobacco and airborne industrial releases.	5 µg/l primary MCL	Accumulative. Causes kidney damage and bone disturbances. Cadmium is classified as a B-1 carcinogen, probably cancer-causing in humans.
Cyanide	Waste from mining, steel, coking and electroplating.	0.2 mg/l primary MCL (proposed)	Acutely toxic at high levels.
Iron	Natural conditions, industrial wastes, corrosion of pipes and other equipment.	300 µg/l secondary MCL	An essential elements for plant and animal life. High concentrations can produce undesirable taste and red/orange color as well as plumbing problems associated with iron bacteria.
Manganese	Natural conditions. Most often found in acidic waters. Difficult to remove.	50 µg/l secondary MCL	An essential element for plant and animal life. High concentrations can produce undesirable taste and gray/black color as well as plumbing problems associated with manganese bacteria.
Selenium	Natural conditions, livestock feed additive. May be elevated due to irrigation practices that concentrate salts at the surface.	50 µg/l primary MCL	Necessary for skeletal and muscular health, and cancer prevention in trace amounts. Toxic at higher levels causing numbness in limbs, gastrointestinal problems, dental damage.
Zinc	Natural conditions, urban, industrial and mining waste.	5000 µg/l secondary MCL	An essential element for plants and animals with no known health risks to humans at concentrations found in water.

Primary and secondary standards are established by the USEPA for regulation of public drinking water supplies. MCL=maximum allowable contaminant level. Secondary MCLs are suggested for non-health related, aesthetic concerns such as taste, odor, color and mineral buildup. Primary MCLs are established for health related concerns.

Constituent	Potential Sources	Standards or Categories	Significance
Nitrate	Fertilizers, sewage and decaying organic matter.	10 mg/l primary MCL	Encourages algal growth, producing undesirable taste and odor. Boiling water will not get rid of nitrate. Concentrations over 10 mg/l can cause illness and death in infants under 6 months in age, decreasing ability of blood to carry oxygen. Blue baby syndrome symptoms in infants: blueness to skin and shortness of breath. Not recommended for consumption by pregnant women (MMWR 7/5/96).
Ammonia	Animal and human waste, and fertilizers.	No human health standards, but standards exist for the protection of fish and aquatic organisms.	Ammonia is unstable and converts to nitrate with distance or time. It is not natural in ground water and indicates impact from land use. If the source is sewage, then the potential for bacteria contamination is a concern.
Phosphorus	Animal and human waste, fertilizers and detergents	No human health standards, but standards exist for the protection of fish and aquatic organisms.	Encourages algal growth. Concentrations in natural water are normally no more than a few tenths of a milligram per liter. Higher values indicate impact to the ground water. Can be a concern in areas of ground water discharge to surface water.
Gross Alpha Radiation, Adjusted	Natural radioactive decay process.	15 pCi/l after excluding uranium and radon.	High values may indicate the presence of alpha radiation emitters that may cause cancer, such as radium.
Gross Beta Radiation	Human-caused or natural radioactive decay process	50 pCi/l	High values may indicate the presence of beta radiation emitters that may cause cancer, such as thorium and actinium.
Uranium	Natural conditions, phosphate fertilizers, industrial wastes.	20 µg/l primary MCL (proposed)	The primary health risk is kidney damage resulting in loss of nutrients from the body. Over longer periods known to cause cancer, primarily bone tumors.
Radon-222	Product of natural radioactive decay of radium.	Primary MCL proposed: 300 to 3000 pCi/l	Radon gas in soil enters home as airborne radon, which causes lung cancer. Certain housing construction standards minimize this. Radon in ground water may add to airborne radon during normal water use such as showering and dishwashing.

Primary and secondary standards are established by the USEPA for regulation of public drinking water supplies. MCL=maximum allowable contaminant level. Secondary MCLs are suggested for non-health related, aesthetic concerns such as taste, odor, color and mineral buildup. Primary MCLs are established for health related concerns.

Constituent	Potential Sources	Standards or Categories	Significance
Radium-226	Product of natural radioactive decay of uranium.	Primary MCL 5 pCi/l	Radium is an alpha radiation emitter and may cause cancer.
Pesticides	Applications to land or vegetation to kill plant, insect or other threats to crop or land use.	Pesticides have health recommendations. Existing standards differ for different compounds. Contact the Idaho Dept. of Agriculture for specific information.	The presence of any pesticide concentration in ground water is an indication that land use has impacted an aquifer. Health effects of levels that exceed standards may include damage to the liver, kidney and nervous system, cancer and genetic mutations.
Volatile Organic Compounds	Industrial solvents, dry cleaning processes, petroleum products, pesticides, water chlorination by-products.	Many organic compounds have health recommendations. Existing standards differ for different compounds. Contact local health district for specific information.	The presence of any volatile organic compound concentration in ground water is an indication that land use has impacted an aquifer. Health effects of levels that exceed standards may include damage to liver, kidney and nervous system, and cancer.

Primary and secondary standards are established by the USEPA for regulation of public drinking water supplies. MCL=maximum allowable contaminant level. Secondary MCLs are suggested for non-health related, aesthetic concerns such as taste, odor, color and mineral buildup. Primary MCLs are established for health related concerns.

## APPENDIX C - QUALITY ASSURANCE

Quality assurance (QA), in the field and laboratory, was outlined by a QA Plan and Standard Operating Procedures (SOPs) developed jointly by IDWR and USGS. A training video and on-site visits to the field teams provided the opportunity to refine techniques and obtain feedback to help clarify SOPs, simplify logistics and improve subcontractor services.

Quality control samples included: five percent blanks and replicates for all common ions, trace elements and nutrients, lab reruns for results viewed as unusual, five percent splits for nitrate (through 1994), trip and transfer blanks for every field batch (from 1 to 8 samples) of VOC samples, five percent VOC replicate samples (starting in 1995), VOC spikes and spike replicates (in 1995), spikes for gas chromatography pesticides, five percent laboratory duplicates and five percent field duplicates for radiochemical analyses, and analytical batch control samples, field and lab duplicates and confirmation reruns for immunoassay analyses.

In August of 1993, a special study was undertaken to resample sites where analyses had detected the presence of a regulated VOC. One or more samples were taken at each site where well owner permission was granted. One sample from each site was sent to the private contract lab and a splits was sent either to the State Lab or the USGS lab where the samples from 1991 and 1992 respectively, were analyzed. Results confirmed the continued presence of the VOCs and established good correlation between laboratories.

In the spring of 1994, IDA conducted a study to resample all Statewide Program sites where pesticides had been detected through immunoassay. Split samples were taken for both GC and immunoassay analyses and the results compared. Comparability was particularly good for the most commonly detected pesticide, atrazine (Bahr, 1994).

## APPENDIX D - NONPARAMETRIC STATISTICAL TESTS USED IN THIS REPORT

1. Kruskal-Wallis rank-sum test. This test can be used to evaluate whether k number of groups ( $k > 2$ ) have identical distributions or whether at least one group has a different distribution than the other groups. The null ( $H_0$ ) and alternate ( $H_a$ ) hypotheses are:

$H_0$ : All of the k groups of data have identical distributions

$H_a$ : At least one group differs in its distribution.

The shapes of the distributions may be normal, lognormal or anything else. The test is computed using the ranks of the data. The test produces a test statistic and a probability (p). If p is equal to or less than 0.05, the null hypothesis is rejected at the 95 percent confidence level and the alternate hypothesis is preferred. If  $H_0$  is rejected, the reason may be, but is not limited to, a difference in the median values.

References: Conover, 1980; Helsel and Hirsch, 1992.

2. Mann-Whitney rank-sum test. This test is similar to the Wilcoxon rank-sum test with the exception that only two groups (x and y) are tested. The test is used to determine if one group tends to produce larger observations than the other group. The null ( $H_0$ ) hypothesis is:

$H_0$ : Prob ( $x > y$ ) = 0.5 (x will be greater than y one-half of the time)

The alternate ( $H_a$ ) hypothesis is one of the following three statements:

( $H_{a1}$ ): Prob ( $x > y$ )  $\neq$  0.5 (2-sided test; x might be larger or smaller than y), or

( $H_{a2}$ ): Prob ( $x > y$ )  $>$  0.5 (1-sided test; x is expected to be larger than y), or

( $H_{a3}$ ): Prob ( $x > y$ )  $<$  0.5 (1-sided test; x is expected to be smaller than y).

Statement #1 was used as the alternative hypothesis for the Statewide Program analyses. When using the Mann-Whitney rank sum-test, the data can be any distribution shape, similar to the Kruskal-Wallis test. This test is sometimes referred to as the rank-sum test, the Wilcoxon rank-sum test, or the Wilcoxon-Mann-Whitney rank-sum test. The test produces a test statistic and a p value. If the p value is equal to or less than 0.05, the null hypothesis is rejected at the 95 percent confidence level and the alternate hypothesis is preferred.

References: Conover, 1980; Helsel and Hirsch, 1992.

3. Spearman's rho rank-order test. This is a correlation test that measures the strength of the relationship between two variables (x and y). A strong relationship exists either: 1) when x increases, y also increases, or 2) when x increases, y decreases. The test is computed using the rank of the data. The test produces a statistic called rho and a p

value. The null hypothesis is that the correlation is equal to zero (i.e., there is no correlation between x and y; rho is close to zero and p is large). As a correlation becomes a stronger positive one (y increases as x increases), rho will approach 1.0 and p will be very small ( $<0.000$ ). As a correlation becomes a stronger negative one (y decreases as x increases), rho will approach -1.0 and p will be very small ( $<0.000$ ). If the p value is equal to or less than 0.05, the null hypothesis is rejected at the 95 percent confidence level and x is considered to be correlated to y.

Reference: Helsel and Hirsch, 1992.

4. Wilcoxon signed-rank test. This test is used to determine if the difference in the median values between two datasets (x and y) with paired observations ( $x_1y_1$ ,  $x_2y_2$ , etc.) is equal to zero or if there is a significant difference between the medians. It can also be used for a single dataset to determine if the median is significantly greater than or less than zero. The null ( $H_0$ ) hypothesis is:

$H_0$ : median (D) = 0 (the difference between the median of group x and the median of group y is 0)

The alternate ( $H_a$ ) hypothesis is one of the following three statements:

( $H_{a1}$ ): median (D)  $\neq$  0 (2-sided test; the median for group x is expected to be larger or smaller than the median for group y), or

( $H_{a1}$ ): median (D)  $>$  0 (1-sided test; the median for group x is expected to be larger than the median for group y), or

( $H_{a1}$ ): median (D)  $<$  0 (1-sided test; the median for group x is expected to be smaller than the median for group y).

Statement #1 was used as the alternate hypothesis for the Statewide Program analyses. The test produces a statistic and a p value. If the p value is equal to or less than 0.05, the null hypothesis is rejected at the 95 percent confidence level and the alternative hypothesis is preferred.

Reference: Helsel and Hirsch, 1992.

## APPENDIX E - DATA STORAGE AND AVAILABILITY

Statewide Program data is available through the Environmental Data Management System (EDMS), a publicly-accessible database for ground water quality and surface water quality data. EDMS contains water quality data from other sources as well as data from the Statewide Program.

Data may be obtained for the entire state, by county, by latitude and longitude, or by township and range. Laboratory analyses for approximately 50,000 samples collected over a time period of more than 50 years are available. Currently, there are more than 900,000 analytical results with more being added regularly. Inventory information exists on approximately 19,000 sites (wells and springs).

Access to EDMS is available through a dedicated workstation at the Idaho Department of Water Resources, by modem, or the Internet. A state-of-the-art query generator and report writer are available to the EDMS user. A comprehensive user's manual is provided to new accounts. In addition, for requesters who are unable to access EDMS online, searches will be performed on a time available basis.

To request more information about EEMS or to get an account, contact:

Steve Aldridge  
Idaho Department of Water Resources  
1301 N. Orchard  
Boise, ID 83706

Phone: 208-327-5453

Email: [saldrigg@idwr.state.id.us](mailto:saldrigg@idwr.state.id.us)

Homepage:

[Http://www.idwr.state.id.us/idwr/planpol/techserv/gwmon/eems/edmshome.html](http://www.idwr.state.id.us/idwr/planpol/techserv/gwmon/eems/edmshome.html)